Household sector waste to landfill in New Zealand

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1 Introduction

To further its objectives relating to the reduction of waste, the Ministry for the Environment is looking to encourage home composting and reduce food wastage as a means of reducing the amount of organic waste going to landfill. To further this objective, the Ministry contracted Waste Not Consulting Ltd to report on research related to the waste produced by the household sector, with an emphasis on kitchen and garden waste and the environmental effects of their disposal.

The objectives of this research are to provide information on:

- The average composition of waste generated by the household sector that is landfilled
- The per capita generation rates of household sector waste that is landfilled
- The amount of avoidable food waste generated by households
- A comparison of the greenhouse gas emissions resulting from the landfilling of organic household waste compared to home composting
- The effect of landfilling organic household wastes on the loss of soil nutrients and the depletion of organic matter compared to home composting.

Section 1.1 outlines all of the main pathways through which households dispose of unwanted items and materials. Not all of these items and materials will be considered as 'household sector waste' for the purposes of this report. 'Household sector waste' is characterised and quantified in Section 2.

1.1 Disposal pathways for household waste materials

The discarding and disposal of unwanted items and materials from households takes place through a range of pathways. Some of these pathways lead to the landfill disposal of the materials; others lead to their re-use or recovery.

Following is a brief discussion of the main disposal pathways for household wastes. While all of these pathways need to be considered with regards to household organic waste disposal, as this report is focusing on landfill disposal, several pathways are beyond the scope of this research.

1. **Kerbside collections** – A high proportion of New Zealand households are serviced by weekly or fortnightly kerbside recycling and refuse collections. These collections are provided by local authorities and/or private waste operators, using either refuse bags or wheeled bins.

   Most of the material that is collected by kerbside recycling collections is processed locally for re-use, either in New Zealand or overseas. A small proportion of the material from recycling collections is landfilled if it can not be recycled by the processor. Kerbside recycling is not quantified in this report.

   All of the refuse from the refuse collections is disposed of to landfill. Domestic kerbside refuse collections are quantified in Section 2.2.

   A small number of councils provide kerbside organic waste collections. The organic material that is collected is composted. Limited data are available for kerbside organic waste collections, and these collections are not quantified in this report.

Several councils, mainly in the Auckland region, continue to provide annual or biannual kerbside collections of inorganic household waste. A small proportion of material set out for inorganic collections is recovered by the councils' contractors; the remainder is landfilled. Council inorganic kerbside collections are quantified in Section 2.5.

2. **Greenwaste collection services** – In most urban centres, commercial operators will collect greenwaste from households and transport it to either a waste disposal facility or a composting operation (which are frequently situated at disposal facilities). Lawn mowing and landscaping contractors also remove considerable quantities of green waste from residential properties. 'Landscaping' waste, which includes commercial greenwaste collections, that is disposed of to landfill is quantified in Section 2.4.

3. **Self-haul to disposal facilities** – Householders are able to transport all types of waste, including greenwaste and recyclables, to transfer stations or landfills for disposal. A significant proportion of disposal facilities have separate drop-off points for the disposal of greenwaste and recyclables.

   Self-haul waste can include waste generated from residential, landscaping, or construction and demolition activity. Residential self-haul waste is included in the analysis of residential waste in Section 2.3. Landscaping self-haul waste is included in the analysis of landscaping waste in Section 2.4. Construction and demolition waste, unless included incidentally in loads from primarily residential or landscaping activity, is not considered to be 'household sector waste'.

4. **Commercial refuse removal service** – In nearly all parts of the country, householders can pay for a commercial waste operator to provide a skip bin for the removal of refuse or otherwise remove waste from their property.

   Waste removed from residential properties by commercial waste operators can include waste generated from residential, landscaping, or construction and demolition activity. Residential waste transported by commercial waste operators is included in the analysis of residential waste in Section 2.3. Landscaping waste transported by commercial waste operators is included in the analysis of landscaping waste in Section 2.4. Construction and demolition waste, unless included incidentally in loads from primarily residential or landscaping activity, is not considered to be 'household sector waste'.

5. **On-site treatment or disposal** – Some household refuse, particularly in rural areas, is buried or burned on-site by householders. One study in Taranaki found that a majority of farmers burnt their paper and plastic containers, and that 75% fed food waste to farm animals.[1] On-site disposal of household refuse is beyond the scope of this report.

   Organic waste, particularly greenwaste, is composted on-site by many householders. Home composting is discussed in Sections 3 and 4.

6. **Sale or donation of second-hand goods** – An unquantified amount of household items and materials are disposed of through second-hand stores, internet auctions,

[1] Taranaki Rural Sustainability Group (2004) *Investigation into Taranaki's Rural Waste Stream*, prepared for Taranaki Regional Council

charity drop-off boxes, or through other means. As these materials are not disposed of to landfill, they are beyond the scope of this report.

7. **Food waste disposer** – The kitchens of many residential properties, particularly in urban areas, are equipped with in-sink food waste disposal units. The ground food waste is disposed of through a sewerage system, treated at a wastewater treatment plant, and, in most cities in New Zealand, the resulting sewage sludge is disposed of to landfill. The use of food waste disposers is discussed in Section 2.6.

8. **Sewage systems** – Most human waste is disposed of through either on-site septic systems or reticulated sewerage systems. Septic tank sludge is treated in a variety of ways; some of which result in the landfill disposal of the sludge. The sewage sludge from wastewater treatment plants servicing reticulated sewerage systems in urban areas is generally disposed of to landfill. The disposal of human waste is beyond the scope of this report.

2 Household sector waste

2.1 Characterising 'household sector waste'

In Section 1.1, the main disposal pathways for household waste materials are described. For the purposes of this report, 'household sector waste' will include only those materials being disposed of to landfill, excluding construction and demolition waste and waste that is treated at wastewater treatment plants.

The exclusion of construction and demolition waste from 'household sector waste' is in line with the definition of 'Disposal facility' in the Waste Minimisation Act 2008 (Clause 7(2)), which states: '*In subsection (1)(a)(ii), household waste means waste from a household that is not entirely from construction, renovation, or demolition of the house.*'

Figure 2.1 below shows all of the disposal pathways for household waste materials, with those that are classified as household sector waste being highlighted in green. As the figure shows, the four waste streams that make up household sector waste are:

1. Waste generated by residential activity
2. Waste generated by landscaping activity
3. Domestic kerbside refuse collections
4. Inorganic kerbside refuse collections.

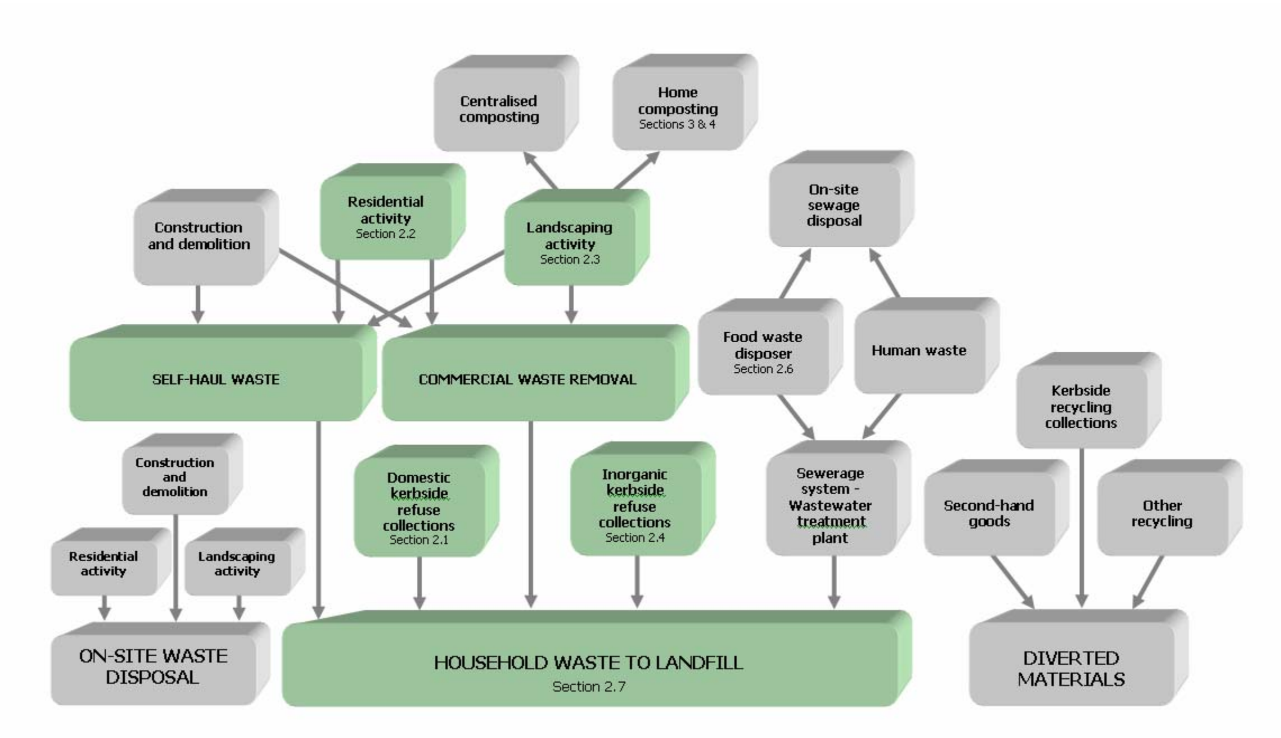

Figure 2.1 – Pathways for the disposal of household wastes and diverted materials

The composition and generation rates for the four waste streams that comprise household sector waste are presented in the sections that follow. The data on those four waste streams are combined in Section 2.7.

2.2 Domestic kerbside refuse collections

Weekly kerbside collections of domestic refuse are available to most households in New Zealand, other than those in remote locations. Most local authorities provide this service, usually through contractors, although a few local authorities do not. In those instances, commercial waste operators provide the only kerbside collections.

Most council-operated kerbside collections are based on plastic or paper 50 to 60 litre refuse bags. A small number of councils provide householders with wheeled bins for kerbside refuse. These wheeled bins range in size from 60 to 240 litres. Some systems are based on the user-pays principle, with householders paying for each refuse bag. A few councils provide a limited number of refuse bags to each property, with the householder paying for additional bags. All councils that provide wheeled bins and a small number of councils that use refuse bags fund the system entirely through rates or a dedicated refuse charge added to rates.

Most commercial waste operators providing kerbside refuse collection services use wheeled bins, although a small number use plastic refuse bags. All provision of services is on a user-pays basis.

A typical compactor load of domestic kerbside refuse discharged at a landfill is shown in Photo 1 below. The load includes both bagged refuse and loose, unbagged refuse from wheeled bins.

Photo 1 - Compactor load of domestic kerbside refuse

The average composition and per capita generation of domestic kerbside refuse generated by households in New Zealand has been calculated as described below.

Methodology for calculating data	The composition data from 14 separate Solid Waste Analysis Protocol (SWAP) audits of domestic kerbside refuse were combined to calculate the composition of domestic kerbside refuse. The data were aggregated proportionally based on the population of the area covered by each audit. The local authority areas included in the audit represented 52% of the total New Zealand population. The per capita per annum figures for the generation of domestic kerbside refuse are based on SWAP audits of 7 separate disposal facilities that, combined, accepted waste from 8% of the population of New Zealand. Annual tonnage data were used, where available, for calculating per capita per annum figures. In most instances, however, it was necessary to extrapolate from weekly data to annual data.
Data accuracy issues	The composition and quantity per household of domestic kerbside refuse varies between bag collections and wheeled bins, between user-pays and rates-funded collections, and differs according to the types of recycling services available in the area. The combination of these different factors in the audits used for the calculations may not accurately reflect New Zealand as a whole. The extrapolation from weekly to annual data reduces the accuracy of the per capita per annum figures, as tonnages of domestic kerbside refuse vary throughout the year. There are no fixed criteria for the sorting of domestic kerbside refuse, and different classifications have been used for different audits. While Waste Not Consulting commonly uses about 30 classifications for these audits, it has been necessary to combine these classifications into the 19 classifications presented in Appendix 2.
References	Ref. 1, Ref. 2, Ref. 3, Ref. 4, Ref. 5, Ref. 6, Ref. 7, Ref. 8, Ref. 9, Ref. 10, Ref. 11, Ref. 12, Ref. 13, Ref. 22, Ref. 23

The average composition and per capita per annum quantity of domestic kerbside refuse is shown in Table 2.1 on the following page. The classifications shown are based on the recommended primary classifications in the Ministry for the Environment's Solid Waste Analysis Protocol 2002 (SWAP). A further breakdown into 19 classifications is provided in Appendix 2.

The results of the calculation show that 153 kg per capita of domestic kerbside refuse are disposed of to landfill each year. Approximately half of this waste is organic, with kitchen waste comprising 40% of the total and greenwaste 10%. Based on standard weight/volume conversion factors[2], the 153 kg per capita per annum of domestic kerbside refuse equates to about 1200 litres or 20 60-litre rubbish bags per person per year. For each New Zealand household (using the Statistics NZ Census 2006 average household figure of 2.6 people per household), this would equate to approximately 400 kg or 3 m^3 or 53 bags disposed each year (i.e. approximately one standard refuse bag per week).

On an annual basis, each person generates 61.2 kg of kitchen waste in domestic kerbside refuse. This is equivalent to about 175 litres of kitchen waste per person per year.

[2] Waste Not Consulting (2008) *Weight/volume conversion factors for waste to landfill,* prepared for Ministry for the Environment

Table 2.1 – Composition of domestic kerbside refuse

Primary category		% of total	Wt per capita per annum
Paper		**14.3%**	**21.9 kg**
Plastics		**12.1%**	**18.6 kg**
Putrescibles	*Kitchen waste*	*40.0%*	*61.2 kg*
	Greenwaste	*9.6%*	*14.7 kg*
	Subtotal	**49.6%**	**75.9 kg**
Ferrous metals		**2.1%**	**3.2 kg**
Non-ferrous metals		**0.9%**	**1.4 kg**
Glass		**3.0%**	**4.6 kg**
Textiles		**3.8%**	**5.8 kg**
Nappies and sanitary		**10.7%**	**16.3 kg**
Rubble		**1.6%**	**2.5 kg**
Timber		**0.7%**	**1.1 kg**
Rubber		**0.2%**	**0.4 kg**
Potentially hazardous		**1.0%**	**1.5 kg**
Total		**100.0%**	**153.1 kg**

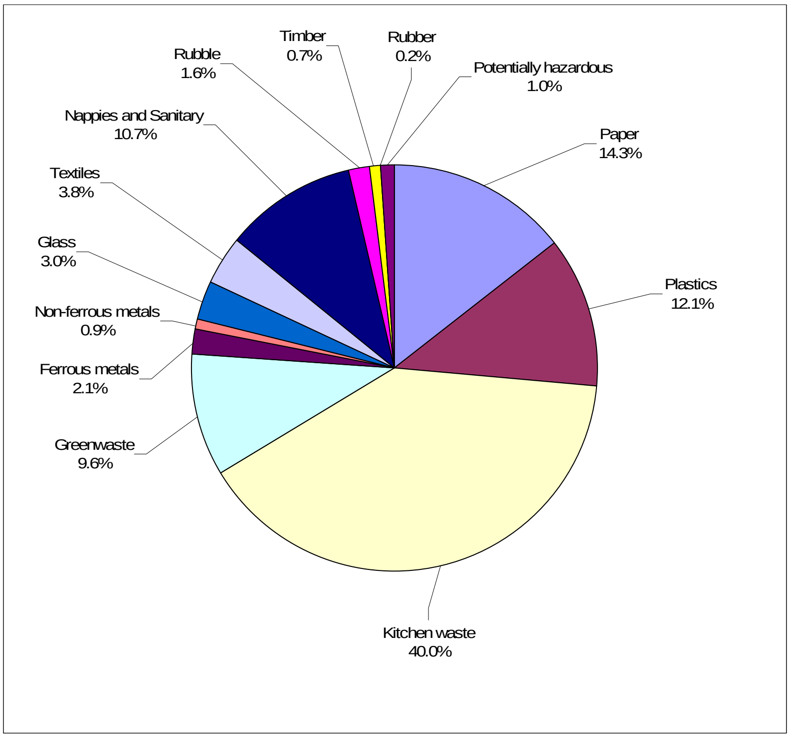

Figure 2.2 – Composition of domestic kerbside refuse

2.3 Residential refuse disposed of to landfill

By definition, for a load of waste to be classified as 'residential' it must be generated by residential activity and cannot be primarily the result of landscaping activity or construction and demolition activity. The disposal of residential refuse is the responsibility of the householder, as opposed to domestic refuse, for which local authorities generally provide kerbside collections.

Residential refuse is usually generated by a household clean-up, resulting in a large amount of refuse being generated in a short period of time, which is then transported to a disposal facility. Residential refuse commonly includes household effects, furniture, soft furnishings, clothes and minor amounts of construction and demolition debris and landscaping waste. Bagged domestic refuse is often included in a load of residential refuse. Residential refuse is usually transported to a disposal facility either by the householder, using a car or trailer, or by a commercial waste operator, using a gantry skip.

'Residential' refuse also includes drop-offs of bagged domestic refuse by householders directly to the disposal facility.

Photo 2 below shows a gantry skip of residential refuse discharged at a landfill. The load includes a range of household effects.

Photo 2 - Gantry skip load of residential refuse

The average composition and per capita generation of residential refuse generated by households in New Zealand has been calculated as described below.

Methodology for calculating data	The composition data from 10 SWAP audits including 14 disposal facilities (both landfills and transfer stations) were used for the calculations. Data were only used from disposal facilities for which it was possible to estimate the population generating the waste stream. Composition data on loads of waste classified as being generated by 'residential' activity were combined to calculate the composition of household refuse. Loads of waste classified as being generated by 'construction and demolition' or 'landscaping' activity were not included. Both self-haul and loads transported by commercial waste operators were included. The data were aggregated proportionally based on the annual tonnage of each waste stream. Annual tonnage data were used where available. In most instances, however, it was necessary to extrapolate from weekly data to annual data. The local authority areas included in the audit represented 19% of the total New Zealand population.
Data accuracy issues	The extrapolation from weekly to annual data reduces the accuracy of the per capita per annum figures, as tonnages of residential refuse vary throughout the year and are influenced by factors such as weather. The weeks during which the SWAP audits were undertaken may not have been representative of a full year's residential refuse. Most, but not all, of the SWAP audits used for the calculations include three categories for organic materials. To amalgamate the data, it has been necessary to reduce the three categories to two by distributing the 'Multimaterial/other' category between the 'Kitchen waste' and 'Greenwaste' categories. As the 'Multimaterial/other' category is generally only 2-3% of the total, the accuracy of the results are not substantially decreased. The per capita data do not take into account any trans-boundary movement of waste that may occur relative to the disposal facilities used for the calculations. For the facilities used for the calculations, this effect is considered to be minor.
References	Ref. 5, Ref. 11, Ref. 12, Ref. 13, Ref. 14, Ref. 15, Ref. 16, Ref. 17, Ref. 18, Ref. 19

The average composition and per capita per annum quantity of residential refuse is shown in Table 2.2 on the following page. The classifications shown are based on the 12 primary classifications recommended in the SWAP, with the 'Putrescibles' category being broken into two secondary categories – 'Kitchen waste' and 'Greenwaste'.

The results of the calculation show that 54 kg per capita of residential refuse are disposed of to landfill each year. Approximately one-quarter of this waste is timber. Putrescible material comprises 17% of the total, with kitchen waste comprising 6% of the total and greenwaste 11%.

Using a weight/volume conversion factor of 200 kg/m^3,[3] the annual quantity of residential waste is equivalent to approximately 265 litres per person. For each NZ household (using the Statistics NZ 2006 average household figure of 2.6 people per household), this equates to 140 kg or 0.7 m^3 disposed of each year (equivalent to 3 large 240-litre wheeled bins).

[3] Waste Not Consulting (2008) *Weight/volume conversion factors for waste to landfill,* prepared for Ministry for the Environment

Table 2.2 – Composition of residential refuse

Primary category		% of total	Wt per capita per annum
Paper		**8.9%**	**4.8 kg**
Plastics		**10.1%**	**5.4 kg**
Putrescibles	*Kitchen waste*	*5.6%*	*3.0 kg*
	Greenwaste	*11.2%*	*6.0 kg*
	Subtotal	**16.8%**	**9.0 kg**
Ferrous metals		**12.0%**	**6.5 kg**
Non-ferrous metals		**0.7%**	**0.4 kg**
Glass		**3.6%**	**2.0 kg**
Textiles		**12.8%**	**6.9 kg**
Nappies and sanitary		**1.5%**	**0.8 kg**
Rubble		**6.5%**	**3.5 kg**
Timber		**25.2%**	**13.5 kg**
Rubber		**1.0%**	**0.5 kg**
Potentially hazardous		**0.8%**	**0.4 kg**
Total		**100.0%**	**53.7 kg**

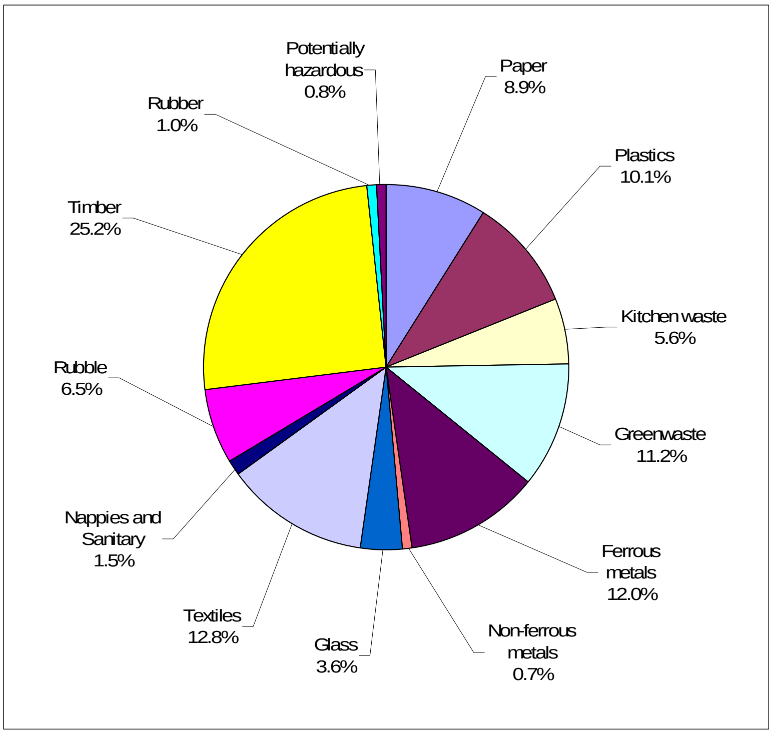

Figure 2.3 – Composition of residential refuse

2.4 Landscaping refuse disposed of to landfill

Loads of waste classified as being generated by landscaping activity commonly include greenwaste, soil, concrete, and smaller amount of man-made materials such as timber (from fences and retaining walls, for instance.

While most disposal facilities have separate drop-off points for waste loads composed totally of greenwaste, mixed loads that include other materials must be disposed of with general refuse. Certain types of plant material can not be readily processed or composted and are considered to be contaminatants. These types of plants, which include bamboo, flax, and cabbage trees, are disposed of with general waste and landfilled.

Loads of landscaping waste are commonly delivered to disposal facilities by householders in trailers, utes, or small trucks. Commercial landscaping contractors also dispose of considerable quantities of contaminated greenwaste. Loads of greenwaste transported by commercial greenwaste collectors do not (in theory) include contaminants and are disposed of to composting facilities rather than being landfilled as general waste.

The trailer load of greenwaste shown in Photo 3 below is likely to have been considered non-compostable by the operator of the greenwaste drop-off facility and is being disposed of with general waste.

Photo 3 - Trailer load of landscaping waste

The average composition and per capita generation of landscaping waste generated by households in New Zealand has been calculated as described below.

Methodology for calculating data	The composition data from 10 separate SWAP audits of transfer stations were used for the calculations. As most loads of landscaping-type waste being disposed of directly to landfill do not originate from residential activity but from construction and earthworks activity, landfill data have not been included. Data were only used from transfer stations for which it was possible to determine the population generating the waste stream. Composition data on loads of waste classified as being generated by 'landscaping' activity were combined to calculate the composition of household landscaping refuse. To determine the composition, the data were aggregated proportionally based on the annual tonnage of each waste stream. Annual tonnage data were used where available. In most instances, it was necessary to extrapolate from weekly data to annual data. The local authority areas included in the audits represented 19% of the total New Zealand population.
Data accuracy issues	Waste Not's methodology for classifying waste loads does not differentiate between landscaping loads from residential and other sources, so it has been necessary to arbitrarily assume that all transfer station landscaping loads are residential in origin and all landscaping loads to landfill are non-residential in origin, except in those instances where there is only one disposal facility serving a community. This arbitrary distinction may not accurately reflect the source of landscaping waste. The quantity of landscaping waste disposed of at a facility varies according to the availability of greenwaste recycling at the facility. The mix of transfer stations used for the calculations may not accurately represent all transfer stations in New Zealand. In some parts of the country, greenwaste generation is seasonal in nature. All of the audits from which data have been taken were of one-week duration, and the data have been extrapolated to represent the entire year. The result may not accurately reflect the annual greenwaste disposal at the facility.
References	Ref. 5, Ref. 10, Ref. 11, Ref. 12, Ref. 13, Ref. 14, Ref. 15, Ref. 16, Ref. 17, Ref. 18, Ref. 19

The average composition and per capita per annum quantity of landscaping waste is shown in Table 2.3 on the following page. The classifications shown are based on the 12 primary classifications recommended in the SWAP, with the 'Putrescibles' category being broken into two secondary categories – 'Kitchen waste' and 'Greenwaste'.

The results of the calculations show that 47 kg per capita of landscaping refuse from households are disposed of to landfill each year. Approximately two-thirds of this waste is greenwaste. Rubble, mainly soil, comprises 26% of the total, with timber comprising 5%.

Table 2.3 – Composition of landscaping waste

Primary category		% of total	Wt per capita per annum
Paper		**0.8%**	**0.4 kg**
Plastics		**1.0%**	**0.4 kg**
Putrescibles	*Kitchen waste*	*0.0%*	*0.0 kg*
	Greenwaste	*64.7%*	*30.3 kg*
	Subtotal	**64.7%**	**30.3 kg**
Ferrous metals		**1.0%**	**0.5 kg**
Non-ferrous metals		**0.1%**	**0.0 kg**
Glass		**0.3%**	**0.1 kg**
Textiles		**0.6%**	**0.3 kg**
Nappies and sanitary		**0.1%**	**0.1 kg**
Rubble		**26.0%**	**12.2 kg**
Timber		**5.2%**	**2.5 kg**
Rubber		**0.1%**	**0.0 kg**
Potentially hazardous		**0.1%**	**0.0 kg**
Total		**100.0%**	**46.8 kg**

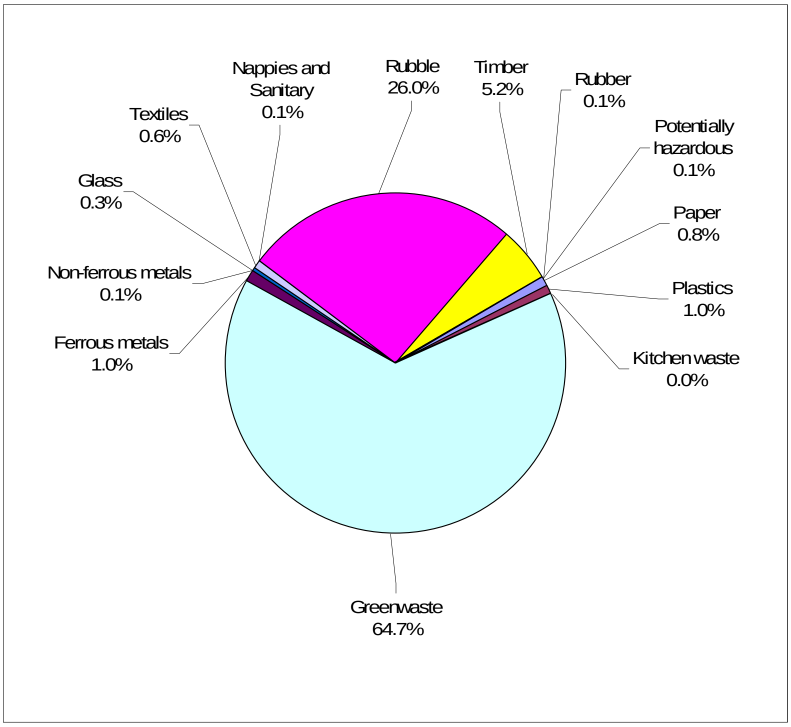

Figure 2.4 – Composition of landscaping refuse

2.5 Inorganic kerbside refuse collections

Kerbside collections of inorganic refuse are provided by a small number of local authorities in New Zealand, primarily in the Auckland region. This service is provided to about 1.2 million people in the Auckland region. The number of councils providing city-wide collections is diminishing, with alternatives such as user-pays collections being introduced.

Most of the material that is collected by the council contractors is landfilled, although, in recent years, some degree of resource recovery has been required by most of the contracts. A substantial (but unquantified) proportion of re-usable items and recoverable materials have traditionally been removed from kerbside inorganic refuse by both amateur and professional 'scavengers'. The recovery rate varies according to economic conditions and, particularly, the price for scrap metals.

Photo 4 shows a typical pile of inorganic refuse. Inorganic refuse includes mainly household effects, with some construction and demolition material. Greenwaste, concrete, and potentially hazardous materials are banned from inorganic collections. The health and safety issues arising from the placement of the refuse alongside major roads, such as in the photo, are one of the reasons that councils are moving away from inorganic kerbside collections.

Photo 4 - Inorganic kerbside refuse

The average composition and per capita generation of inorganic kerbside refuse generated by households in New Zealand has been calculated as described below.

Methodology for calculating data	The composition data from two separate SWAP audits of inorganic refuse collections were used to calculate the composition data. The local authority areas included in the audits represented 50% of the population that are provided with inorganic kerbside collections. The per capita per annum generation rate was calculated by applying the total annual tonnage from all inorganic kerbside collections in the Auckland region to the entire population of New Zealand.
Data accuracy issues	The composition of kerbside inorganic refuse varies with the amount of scavenging that occurs. The scavenging in local authority areas not included in the audits may vary from that in the areas included in the audits. Areas that are provided with kerbside inorganic refuse collections may generate less residential refuse. This has not been taken into account in the calculations for residential refuse generation.
References	Ref. 20, Ref. 21

The average composition and per capita per annum quantity of inorganic refuse collections is shown in Table 2.4 on the following page. The classifications shown are based on the 12 primary classifications recommended in the SWAP, with the 'Putrescibles' category being broken into two secondary categories – 'Kitchen waste' and 'Greenwaste'.

The results of the calculations show that in those areas provided with an inorganic kerbside collection (totalling about 1.2 million residents), 24 kg per capita of inorganic refuse from households are disposed of to landfill each year. The total tonnage collected in those areas equates to 7 kg per capita per year for the total population of New Zealand.

Timber is the largest component of inorganic refuse, comprising 44% of the total. Ferrous metals is the second largest component, comprising nearly 20% of the total.

Table 2.4 – Composition of inorganic refuse collections

Primary category		% of total	Wt per capita per annum – population provided with inorganic collections	Wt per capita per annum – total population of New Zealand
Paper		**4.7%**	**1.1 kg**	**0.3 kg**
Plastics		**5.7%**	**1.4 kg**	**0.4 kg**
Putrescibles	*Kitchen waste*	*0.5%*	*0.1 kg*	*0.0 kg*
	Greenwaste	*0.6%*	*0.1 kg*	*0.0 kg*
	Subtotal	**1.1%**	**0.3 kg**	**0.1 kg**
Ferrous metals		**19.3%**	**4.6 kg**	**1.3 kg**
Non-ferrous metals		**0.6%**	**0.1 kg**	**0.0 kg**
Glass		**3.0%**	**0.7 kg**	**0.2 kg**
Textiles		**11.8%**	**2.8 kg**	**0.8 kg**
Nappies and sanitary		**0.0%**	**0.0 kg**	**0.0 kg**
Rubble		**7.8%**	**1.9 kg**	**0.5 kg**
Timber		**44.5%**	**10.5 kg**	**3.0 kg**
Rubber		**0.8%**	**0.2 kg**	**0.1 kg**
Potentially hazardous		**0.8%**	**0.2 kg**	**0.1 kg**
Total		**100.0%**	**23.7 kg**	**6.9 kg**

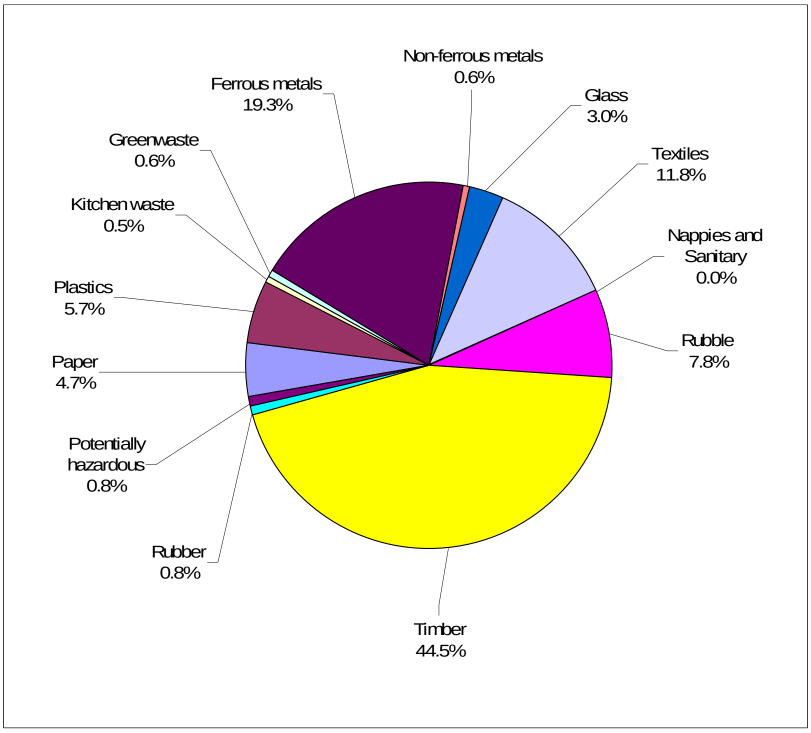

Figure 2.5 – Composition of inorganic refuse collections

2.6 Food waste disposers

Food waste disposers are electric motor-driven appliances that are installed beneath domestic sinks. Food waste is ground up by the devices to a sufficiently small particle size that it can be transported through the domestic plumbing and reticulated sewerage system with the other household sewage.

Research conducted for Parex Industries Ltd (distributor of InSinkErator brand food waste disposers) in 2004 indicates that about 34% of New Zealanders have a waste disposal unit in their home.[4] A 2000 telephone survey of 300 residents of Waitakere City had a similar result, finding that 25% of respondents reported that their "main method of getting rid of kitchen waste" was to "put it down a waste disposal unit".[5]

Considerable controversy exists over the effect of food waste disposers on municipal sewage systems and wastewater treatment plants. This and other issues relating to the use of food waste disposers are discussed in Appendix 3.

Despite the considerable amount of research that has been undertaken relating to food waste disposers in recent years, there seems to be little research on the actual proportion of a household's food waste that is typically disposed of through the device. Many types of food waste can not be readily processed by food waste disposers, so it is not possible to quantify the effect that they actually have on the landfilling of food waste.

[4] TNS (2004) *Parex Appliances 2004 Stage Two Report*, prepared for Parex Industries Ltd
[5] Stones-Havas, T (2000) *Public Perception of Waste Management Issues* Prepared for Waitakere City Solid Waste Business Unit

2.7 Household sector waste to landfill

By adding together the per capita per annum generation rates for the four waste streams described in Sections 2.2 to 2.5, the total household sector waste generation rate can be calculated, as shown in Table 2.5. Using Statistics NZ census data of a New Zealand population of 4,027,947[6], the total tonnage of waste generated by the household sector can also be calculated.

Table 2.5 – Household sector waste to landfill

Waste type	Weight per capita per annum	NZ total wt per annum to landfill
Domestic kerbside collections	153 kg	616,734 T/annum
Residential waste	54 kg	216,312 T/annum
Landscaping waste	47 kg	188,320 T/annum
Inorganic refuse collections	7 kg	27,627 T/annum
Total	**260 kg**	**1,048,993 T/annum**

Over one million tonnes of waste to landfill are generated by the household sector each year, an average of 260 kg per person. Using the Statistics NZ average of 2.6 people per household, each household in New Zealand generates 676 kg of waste to landfill.

Based on an uncompacted density of 200 kg/cubic metre[7], this is equal to 1.3 cubic metres per person per year, or 3.38 cubic metres per household per year of household sector waste to landfill. This is the equivalent of 5.4 large, 240-litre wheeled bins per person, or 14.1 large, 240-litre wheeled bins per household.

The 1.05 million tonnes of household sector waste disposed of to landfill each year would have an uncompacted volume of 5,244,965 cubic metres. The 1.05 million tonnes of uncompacted household sector waste would:

- Cover a 70 metre x 100 metre rugby field to a depth of 750 metres
- Cover 740 quarter-acre sections to the height of a two-storey house (7 metres)
- Fill 52,450 semi-trailer trucks (at 20 tonnes per truck), which would stretch for 944 km if placed nose to tail

By combining the composition of each waste stream, based on the relative size of each waste stream, the composition data presented in Table 2.6 and Figure 2.6 on the next page can be calculated. Over 44% of household sector waste is organic, with 25% of the total being kitchen waste. Paper and plastic are the second and third largest categories, comprising 11% and 10% respectively.

The 258,886 tonnes of kitchen waste would have a volume of 735,672 cubic metres, and cover the playing area of a rugby field to a depth of over 100 metres. This is equivalent to 183 litres of kitchen waste per person per year.

[6] http://www.stats.govt.nz/census/2006-census-data/quickstats-about-nzs-pop-and-dwellings/quickstats-about-nzs-pop-and-dwellings-revised.htm?page=para001Master
[7] Waste Not Consulting (2008) *Weight/volume conversion factors for waste to landfil*l, prepared for Ministry for the Environment, unpublished

Table 2.6 – Household sector waste to landfill

Primary category		% of total	Wt per capita per annum	NZ total per annum
Paper		10.5%	27 kg/annum	110,374 T/annum
Plastics		9.5%	25 kg/annum	100,010 T/annum
Putrescibles	*Kitchen waste*	*24.7%*	*64 kg/annum*	*258,886 T/annum*
	Greenwaste	*19.6%*	*51 kg/annum*	*205,526 T/annum*
	Subtotal	44.3%	115 kg/annum	464,422 T/annum
Ferrous metals		4.4%	11 kg/annum	46,298 T/annum
Non-ferrous metals		0.7%	2 kg/annum	7,294 T/annum
Glass		2.6%	7 kg/annum	27,749 T/annum
Textiles		5.3%	14 kg/annum	55,466 T/annum
Nappies and sanitary		6.6%	17 kg/annum	69,272 T/annum
Rubble		7.2%	19 kg/annum	75,076 T/annum
Timber		7.7%	20 kg/annum	81,023 T/annum
Rubber		0.4%	1 kg/annum	3,977 T/annum
Potentially hazardous		0.8%	2 kg/annum	8,033 T/annum
Total		100.0%	260 kg/annum	1,048,993 T/annum

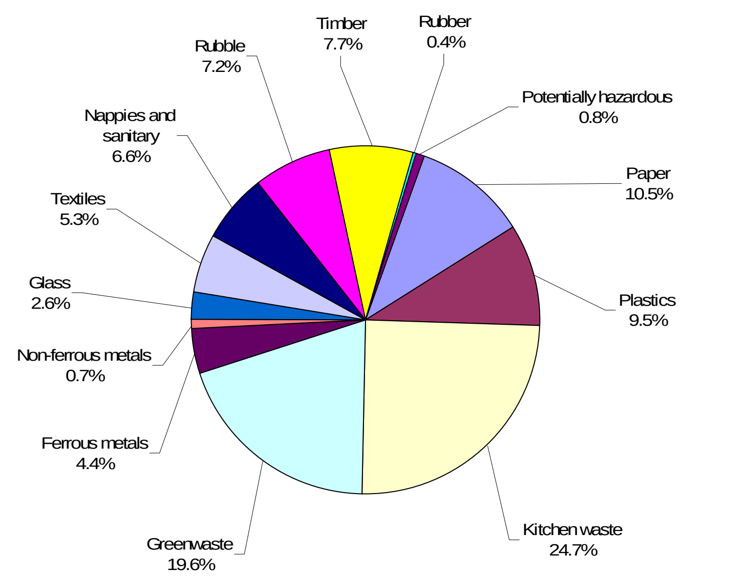

Figure 2.6 – Composition of household sector waste to landfill

3 Organic household waste and climate change

Summary

1) Carbon dioxide and methane are the most important greenhouse gases produced by the decay of organic household waste. Methane is 24 times as powerful a greenhouse gas as carbon dioxide. Carbon dioxide is produced when sufficient oxygen is available (aerobic conditions); methane is produced in the absence of oxygen (anaerobic conditions).

2) For the purposes of greenhouse gas inventory methods, the Intergovernmental Panel on Climate Change does not consider carbon dioxide produced by the decay of organic matter to be a greenhouse gas emission. Methane produced from the decay of organic matter, such as in a landfill, is considered to be a greenhouse gas emission.

3) Carbon dioxide emitted from organic household waste that is treated through an aerobic composting process is not accounted for as a greenhouse gas emission, as it is considered to be part of the natural carbon cycle of photosynthesis and decomposition.. Occasionally, home composting can become anaerobic, emitting methane, but there is very little research quantifying this phenomenon. When methane is emitted from composting, it is classified as anthropogenic in origin, and is considered to be a greenhouse gas emission.

4) Organic matter that is landfilled decays aerobically for a period of time until oxygen is no longer available and then decays anaerobically, producing methane. Different types of organic matter decay at different rates in a landfill, with materials such as food waste decaying much more quickly than woody garden waste.

5) Some landfills (22% of those in New Zealand) have reticulated pipe systems for recovering methane gas from the decaying waste mass. There is considerable controversy regarding the proportion of generated methane that is recovered by these systems. As the pipe systems are not utilised for the recovery of methane until the waste has been in place for several months, methane generated soon after waste is deposited (such as from the decomposition of food waste) may not be captured.

6) A full life-cycle accounting of greenhouse gas emissions from the landfilling of organic household waste compared to those from home composting would need to include a wide range of emissions for landfilling (such as waste transport and landfill operations). There are very few greenhouse gas emissions associated with home composting, as the carbon dioxide that is produced is classified as biogenic in origin, and is not considered to be a greenhouse gas..

The importance of the disposal of organic household waste to the production of greenhouse emissions is recognised internationally. The WRAP website (Waste and Resources Action Programme), the UK government's principal web-based portal for advice and research on recycling and waste minimisation, asserts that "*Recycling more food and garden waste reduces greenhouse gas emissions in the UK and is a key plank in the government strategy on waste*"[8]. A summary research document states "*Home composting is a good way to make better use of peelings and other compostable food waste. Recycling compostable food waste into compost is*

[8] http://www.wrap.org.uk/local_authorities/biowaste/index.html

cheaper than other forms of waste treatment, and unlike landfill does not generate significant levels of methane"[9].

3.1 Greenhouse gases

The six gases that are used to assess the greenhouse impact are: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydro fluorocarbons (HFCs); per fluorocarbons (PFCs); and sulphur hexafluoride (SF_6). The decomposition of organic matter results primarily in either the generation of carbon dioxide or methane, depending on the quantity of oxygen available. If sufficient oxygen is available during the decomposition process, carbon dioxide is produced; if sufficient oxygen is not available, methane is produced.

Not all greenhouse gases have the same climate change potential.[10] Established conventions give carbon dioxide a climate change potential of one and assign a potential to other gases relative to that of carbon dioxide. Methane is given a climate change potential of 24 and nitrous oxide 360.[11] That is, a mass of methane has 24 times the climate change potential of the same mass of carbon dioxide.

The Intergovernmental Panel on Climate Change (IPCC) has developed a set of inventory methods to be used as an international standard. One element that deserves special mention with regards to the disposal of organic household waste is the treatment of carbon dioxide released from biogenic sources. The focus of the Framework on Convention on Climate Change is on anthropogenic emissions – those resulting from human activities and subject to control – as these have the potential to disrupt the natural balance in the carbon cycle and alter the earth's climate.

Consequently, for processes with carbon dioxide emissions, if the emissions are from biogenic materials and the materials are grown on a sustainable basis, the emissions are considered to close the loop in the carbon cycle and return to the atmosphere carbon dioxide that was removed by photosynthesis.

Specifically, this means that the carbon dioxide emitted from organic household waste that is treated through a composting process is classified as biogenic in origin and not considered to be a greenhouse gas emission. If the same organic waste were taken to landfill where it decomposed, releasing methane, and, were the methane released into the atmosphere, the methane emissions would be classified as anthropogenic, and considered to be a greenhouse gas emission. Conversely, if the methane were captured, and flared off or burned for electricity generation, neither the methane captured nor the carbon dioxide released when the methane was burned would be considered a greenhouse gas emission. In the case of electricity generation, the landfilling process could then be credited with avoidance of greenhouse gas emissions by an electrical utility.[12] Similarly, organic waste incinerated at a waste-to-energy facility would gain emission credits for energy produced (replacing energy from other producers creating greenhouse gases).

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[9] Waste and Resources Action Programme (WRAP). (2007). *Research Summary: Understanding food waste.* http://www.wrap.org.uk/downloads/FoodWasteResearchSummaryFINALADP29_3__07.0ddcd4fb.3659.pdf

[10] Much of this section has been adapted from Waste Not Consulting (2002) *Assessment of Options for the Management of Organic Kitchen Waste*, prepared for the Organic Waste Working Group of the Auckland Region Waste Managers Forum

[11] Ministry for the Environment (2001) *Life Cycle Tool for Waste Management in New Zealand WISARD Reference Guide*

[12] USEPA (1998) *Greenhouse Gas Emissions from Management of Selected Materials in Municipal Solid Waste* EPA530-R-98-013 at www.epa.gov

To summarise, according to the conventions of the IPPC Framework, carbon dioxide emissions from any treatment process or disposal of household organic waste *would not* be treated as a greenhouse gas emission. Methane emissions into the atmosphere from any treatment or disposal of household organic waste *would* be treated as a greenhouse gas emission.

3.2 Greenhouse gases from composting

An atom of carbon in organic waste, in simple terms, turns into a molecule of carbon dioxide if oxygen is present (aerobic), or, if no oxygen is present (anaerobic conditions), into a molecule of methane. Composting is, by definition, an aerobic process. Given that the fundamental condition of a composting system is one that requires an oxygen-rich environment (i.e. aerobic conditions) and the fundamental condition for a landfill is one that does not (i.e. an anaerobic environment), in simplest terms the quantity of greenhouse gases contributing to climate change that are generated by the home composting of organic wastes (primarily carbon dioxide) must be far less than those generated by disposing of the same waste to landfill (primarily methane). This is because methane has a much greater climate change potential than carbon dioxide (see Section 3.1). A fuller description of the life cycle analysis of the two systems is given in Section 3.5.

There are, however, situations where methane can be produced in home composting systems and where the methane generated by landfills is captured and recovered via a landfill gas-recovery system, converting it to carbon dioxide. There is not a great deal of research material available relating to the study of home composting systems gas emissions. Studies of well-managed systems indicate that only traces of methane are generated.[13] However, not all home composting systems are properly managed, and the wide range of parameters involved make the accurate quantification of methane generation by home composting very difficult.

3.3 Greenhouse gases from landfill disposal of organic household wastes

The issues surrounding the production and capture of methane by landfills are among the most important and the most contentious with regard to the life cycle assessment of organic waste disposal. Although the issue at first seems to be a minor technical matter, it is in fact fundamental to assessing the environmental effects of landfilling, in particular the landfilling of organic household waste.

Landfill gases are produced as the organic component of the waste decomposes under both aerobic and anaerobic conditions. The generation rate is affected by many factors including refuse composition, waste age and quantity, condition of the waste mass, moisture content, pH, temperature, and the availability of oxygen.[14].

3.3.1 Methane capture at landfills

The most recent census of landfills by the Ministry for the Environment found that 22% of the 60 consented landfills in New Zealand were equipped with landfill gas capture systems for flaring or beneficial use.[15] The census does not provide any tonnage data for landfills, but as

[13] Smith, S and Mitaftsi, O (2005) *Home Composting and its Role in Waste Management*, in Microbiology Today, May 2005, online at http://www.sgm.ac.uk/pubs/micro_today/pdf/050507.pdf
[14] Wetherill, TD (2002) *Management of Landfill Gas: Local Actions Can Provide Global Benefits*, in *What's New in Waste Management*, August/September 2002
[15] Ministry for the Environment (2007) *The 2006/07 National Landfill Census* Online at http://www.mfe.govt.nz/publications/waste/2006-07-national-landfill-census-oct07/2006-07-national-landfill-census-oct07.pdf

gas capture systems are mainly installed at large disposal facilities, the proportion of waste from which gas is captured would be much greater than the proportion of facilities capturing gases.

There are two primary time periods to consider relating to landfill gas escape and capture - before the gas extraction system is installed and after. Before gas extraction system installation, the escape rate of gas can be estimated at 100% of landfill gas being generated. After gas extraction system installation, gas escapes from waste volumes not influenced by the gas system - that is, from any space within the landfill that is not maintained under negative pressure by the gas system.

Complicating the estimation of methane capture rate is the need to take into account both the carbon that is sequestered (i.e. is never converted to gaseous form) and the proportion of methane that is oxidised (i.e. converted to carbon dioxide gas) in the oxygen-rich upper layers of the landfill as the methane rises to the surface. As a result of these complications, the proportion of landfill gas that is generated that is actually captured is the subject of considerable controversy.

An assessment of the effects on greenhouse gas emissions from waste disposal as a result of the implementation of the 2002 New Zealand Waste Strategy was prepared for the Ministry for the Environment in 2002. A 60% overall efficiency rate (for all landfill gas capture systems in New Zealand) was assumed for the period 1990-1999.[16]

The USEPA used a figure of 75% methane capture (and a 10% oxidisation rate as the methane migrates through the refuse mass) for its investigation into greenhouse emissions from municipal solid waste management.[17] Redvale Landfill in Albany, Auckland estimates a methane capture rate of greater than 85%.[18] The Lucas Heights landfill in Sydney reports a 66% methane recovery for flaring and assumes that 50% of non-captured methane is oxidised into carbon dioxide in the landfill cap layer. A literature review conducted as part of the Cooperative Research Centre's investigation in Sydney found a wide range of gas capture rates is given in literature, ranging from 30% up to 85%.[19]

Other sources state that:

- "Methane gas recovery from landfills still only achieves 40%-75% during the lifetime of dedicated recovery facilities"20
- "Information subsequently submitted by Dr Krämer in support of his assertion, in the form of a paper by Hans Willumsen of LFG Consult, Denmark, states that only about 25 to 50% of the gas produced in landfills is recoverable".21
- "Estimates of collection efficiencies vary, 20-25% (De Baere et al., 1987); 40% (RCEP, 1993); 40-70% (Carra and Cossu, 1990); 40-90% (Augenstein and Pacey, 1991), and will depend on size, shape and engineering design of the landfill site. For the purposes of the LCI model in this book, a figure of 40% will be assumed."22

[16] Tonkin & Taylor (2002) *Assessment of Greenhouse Gas Emissions from Waste Disposal as a Result of Implementation of the Proposed New Zealand Waste Strategy*, prepared for the Ministry for the Environment.
[17] USEPA (1998) *Greenhouse Gas Emissions from Management of Selected Materials in Municipal Solid Waste EPA530-R-98-013* at www.epa.gov
[18] Waste Management NZ Ltd (2001*) Environmental Progress Report – 2001 – Meeting Community Expectations*
[19] www.crcwmpc.com.au/Publications/FoodWasteDisposalReport/FoodWasteDisposalReport.pdf
[20] Wallis, MK (1995) *Reassessing methane from UK landfills in Sarsby* (ed.) Waste Disposal by Landfill – GREEN '93 Balkema Rotterdam in Greenhouse Gas Abatement: Landfill vs. Incineration of Municipal Solid Waste at www.scientecmatrix.com
[21] House of Lords Select Committee on European Communities Seventeenth Report at http://www.parliament.the-stationery-office.co.uk/pa/ld199798/ldselect/ldeucom/083xxvii/ec1706.htm#note33
[22] White, P (1999) *Integrated Solid Waste Management: A Lifecycle Inventory*, Aspen Publishing as quoted by Peter Anderson, Editor, Recycleworlds magazine, personal communication

- "Modern sanitary landfills sites that are designed for methane recovery yield only 30-40 per cent of the amount of gas actually generated."23

3.3.2 Decomposition of organic waste in landfills

Apart from methane capture rates, which measure the proportion of gas that is extracted after the extraction systems have been installed in a particular waste mass, the actual rate of decay of the different materials is pivotal to this issue, but is seldom taken into account in calculating overall capture rates. Some organic materials, such as branches, timber, and leaves decay very slowly and result in a net sequestration of carbon in a landfill. Other materials, such as food waste and office paper, decay much more quickly and result in net emissions of carbon.[24] Much of this decomposition may occur prior to gas extraction systems being activated within the waste mass.

There is little research available on the subject. What data there are on rates of decomposition of materials in a landfill vary greatly. The existing literature was investigated extensively by Dane County, Wisconsin, and the half-life for the decomposition of food waste was found to be given as anywhere from 0.5 to 2.8 years.[25] The County was investigating whether the exclusion of food waste from its landfill would result in a decrease in methane capture.

An Australian government workbook for waste management gives the half-life (time taken for decomposition into landfill gas of half of the degradable content) for organic materials as being:[26]

- Food – 1 year
- Garden – 5 years
- Cardboard – 15 years.

Transpacific Industries (NZ) Ltd Redvale Landfill, north of Auckland, estimates the overall half-life for the organic component of its waste stream is on the order of 10-11 years. On the basis of this, a half-life for food of 0.5-5 years is posited by technical staff.[27]

The decay rate of household organic waste is important because aerobic decomposition of the highly putrescible component begins even before the material is collected from a resident's house. One of the reasons for daily cover at a landfill is to stop the rapid aerobic decomposition as quickly as possible and ensure that further decomposition is anaerobic and methane generating, which is much slower, reducing the quantity of landfill gases of all kinds that are released and making more methane available for capture later. The characteristic odours of anaerobic decomposition are often detectable on the surface at Redvale within a few months of waste being deposited, indicating that aerobic decay has abated.

The capture of landfill gas by vacuum extraction does not begin until after the waste is covered and the extraction piping installed. After extraction starts, oxygen levels within the landfill gas are used as a guide for extraction rates from a landfill cell. The extraction rates are managed to balance the risk of drawing excess oxygen into the system and creating a risk of spontaneous

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[23] *Methane capture and use – waste management workbook* Online at http://www.greenhouse.gov.au/pubs/methane/mwbpartb.html#B1.2
[24] USEPA (1998) *Greenhouse Gas Emissions from Management of Selected Materials in Municipal Solid Waste* EPA530-R-98-013 at www.epa.gov
[25] Reindl, J (2002) Recycling Manager, Dane County Wisconsin, personal communication
[26] *Methane capture and use – waste management workbook* Online at http://www.greenhouse.gov.au/pubs/methane/mwbpartb.html#B1.2
[27] Bruce Horide, Redvale landfill, personal communication

combustion against obtaining the maximum amount of methane and odorous constituents in the gas.

At Redvale Landfill, it is reported that typically a period of six to nine months may expire prior to the extraction process beginning. If organic wastes with a high moisture content, such as sewage sludge, have been deposited, the extraction may begin in as little as three to six months.[28]

Given the large number of variables involved, and the lack of scientific research on the subject, it is difficult to estimate the proportion of household organic waste that undergoes anaerobic decomposition in a landfill environment, nor is it possible to estimate with certainty the proportion of the methane that escapes to atmosphere or is captured.

3.4 Estimating greenhouse gas emission factors in New Zealand

The greenhouse gas emission factors recommended to be used to determine the equivalent tonnes of carbon dioxide emissions (CO_2-e) produced by organic waste in landfills are published and updated each year in a Ministry for the Environment publication.[29] *Guidance for voluntary, corporate greenhouse gas reporting* is a guide which provides emission factors and methodologies to help organisations estimate their emissions from a range of gas-producing sectors and activities including waste disposed of at a landfill.

The current emission factor for "garden and food waste" disposed to a landfill without a landfill gas-recovery system is 0.945 and 0.559 for landfills that have a gas recovery system. This means for every 1 tonne of organic waste landfilled, the equivalent of 0.945 tonnes of CO_2-e is produced. Approximately half a tonne (0.559 T) would be produced if the landfill had a gas recovery system in place. These figures confirm that landfill gas recovery systems, while reducing the overall CO_2-e produced by organic wastes, does not eliminate it completely.

The emission factors for waste disposed to landfill are based on figures from New Zealand's Greenhouse Gas Inventory 1990–2006 and methodologies are derived from IPCC good practice guidance. For the sake of simplicity in accounting, the methodology assumes all the potential emissions in a tonne of waste are released in the year of disposal.

3.5 Life cycle assessment of greenhouse gas emissions from waste disposal

Regardless of the efficiencies of landfill gas recovery systems, greenhouse gas emissions are produced through the collection and landfill disposal of household organic waste that are not generated through home composting. A full life cycle assessment of household organic waste being disposed of to landfills would need to consider the following aspects:

- Manufacture of collection containers (bags or wheelie-bins)
- Manufacture of collection vehicles
- Energy consumption and exhaust emissions of collection vehicles
- Manufacture of landfill equipment (for construction and operation phases)
- Energy consumption and emissions of landfill equipment (for construction and operation phases)
- Gas emissions from landfill and/or avoided gas emissions from electricity generation (where applicable)

[28] Bruce Horide, Redvale landfill, personal communication
[29] Ministry for the Environment (2007). *Guidance for voluntary, corporate greenhouse gas reporting.* http://www.mfe.govt.nz/publications/climate/guidance-greenhouse-gas-reporting-2008-09/html/index.html

- Liquid emissions from landfill.

A full life-cycle assessment for home composting would not require the majority of the components listed above, given that negligible transport, handling and equipment is required to home compost organic wastes.

As an indication of the impact that collection and handling can have on the overall greenhouse gas generation, a UK study reported that the anthropogenic greenhouse gas emissions generated by centralised collection and in-vessel treatment of food waste were greater than those associated with household treatment by a factor of between 10 and 40.[30]. It is noted that the centralised system investigated for this study was not a landfill but rather an in-vessel aerobic digestion process and the household treatment was a food waste digestion system, however the collection and handling aspects for the two systems are comparable to a landfill versus a home-composting system scenario.

Another UK study compared the overall greenhouse gases generated by a community-scale centralised composting system compared with a landfill option. The study accounted for the greenhouse gases produced via the transportation, processing and post-processing stages for both options. Overall the composting option produced the equivalent of less than half the quantity of CO_2-e compared to the landfilling option.[31]

[30] Knipe (2007). *Comparison of Greenhouse Gas Emissions from the Centralised and Household Treatments of Food Waste.* Environmental Research & Consultancy. Online at http://www.greencone.com/uploads/publications/Carbon_Paper.pdf
[31] De Selincourt, K (2008). *A comparison of greenhouse gas flux from composting compared to landfill and fertilizer production.* The Growing Heap. Online at www.communitycompost.org/info/GHG%20compost.doc

4 Organic household waste and the soil

Summary

1) The composting of organic household waste produces carbon dioxide, water vapour, energy, and a stabilised organic component that continues to slowly degrade over time.

2) The practice of home composting is highly variable, ranging from poorly-managed static piles to well-managed bin systems. In response to telephone surveys, anywhere from 30-67% of households claim to compost. The actual proportion of 'active' composters is thought to be considerably lower.

3) Finished compost is not high in nutrients, being the equivalent of a dilute fertiliser. While suitable for some purposes, compost on its own may not contain sufficient nutrients to maintain nutrient levels in agricultural or horticultural soils.

4) Compost is most beneficial as a soil amendment because of the organic matter that it adds to soils. Organic matter is essential to plant growth, and heavy cropping of soils results in a decrease in organic matter.

5) The landfilling of organic household wastes results in a complete loss of the nutrients and organic matter produced when the waste decays.

6) Home composting does not 'close the loop'. While home composting will result in an improvement to the soils to which the compost is applied, this does not address the problem of the degradation of the soils that produce the fruit and vegetables consumed by the householder. In this regard, centralised composting operations may be advantageous compared to home composting, particularly when the compost from large-scale composting operations is used by commercial growers.

4.1 Composting

By definition, composting is the aerobic decomposition of biodegradable organic matter such as organic household waste. The decomposition is enabled by bacteria, yeasts and fungi, and larger organisms.

Initially, bacteria partially degrade organic material, such as organic household waste, into water vapour and gases. Other micro-organisms then feed on the remaining material, resulting in a significant volume reduction.[32] The process releases energy in the form of heat which kills pathogens as well as having a drying effect on the material. When the process is complete a stable product remains that has beneficial properties as a soil conditioner[33]. The stabilised organic component will continue to degrade, but at a greatly reduced rate.

Composting systems are designed to accelerate the decomposition of the readily-degradable organic matter, such as food waste, most of which is degraded to carbon dioxide. The process

[32] UNEP, 1996. *International Source Book on Environmentally Sound Technologies for Municipal Solid Waste Management.* IECT Technical Publication Series 6. United Nations Environment Programme http://www.unep.or.jp/ietc/ESTdir/Pub/MSW/index.asp

[33] AWMTPI, 2000. *Report of the Alternative Waste Management Technologies and Practices Inquiry*. Prepared by the Alternative Waste Management Technologies and Practices Inquiry for the State Government of New South Wales. State Government of New South Wales, Office of the Minister for the Environment at www.epa.nsw.gov.au/waste/

can be as simple as a pile of garden material in a residential section or as technologically-advanced as a high-tech automated in-vessel system. The quality of the environmental outcomes, especially in terms of methane emissions, is dependent on appropriate management of the system. The quality of the final product, in terms of contamination and nutrient levels, is highly dependent on the treatment process and the feedstock.[34]

4.1.1 Home composting

'Home composting' encompasses a wide range of technologies and practices, from open piles to purpose-designed commercially-produced containers. Householders may compost exclusively with lawn clippings, garden waste, or organic kitchen waste or may combine a variety of materials. While open piles may be suitable for the composting of garden waste, enclosed systems are preferable for composting organic kitchen waste to minimise odour, rodent, and insect problems.

Management of home compost systems is also highly variable. Active composters concerned with harvesting a high-quality product may layer the compost pile as it is constructed with different materials and add various amendments to improve the nutrient content and accelerate the process. Others may do little more than dispose of organic kitchen waste into a container until it is full or accumulate organic material indefinitely in a pile.

Vermicomposting (worm farming) has recently risen in popularity as a means of disposing of household food waste. Several brands of commercially produced purpose-designed bins are available. A home vermicomposting system requires only a dedicated food scrap container for kitchen use that is emptied into the worm bin. The bins produce both a compost product containing the worm castings that can be used as a soil amendment, and vermiliquid, which can be used as a liquid fertiliser.

The proportion of households that compost can vary substantially, depending on a range of factors.[35] These factors include the climate, how urban the environment is, the age of the population, the proportion of households with gardens, and the degree of promotion of home composting. Basically, home composting is strongly linked to gardening.

A recent survey of Christchurch households found that around 57% of people compost at home. The same survey found that 60% of households dispose of their kitchen organics in either refuse bags or waste disposal units in the sink.[36]

Rural composting rates tend to be higher. Rates of 67% percent are reported for Franklin District in the North Island, 59% for Hauraki District, and 50% for the Waikato Region.[37]

The proportion of households composting at home has been the subject of several studies in the Auckland region. A 1996 study found that 40% of households report that they usually

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[34] UNEP, 1996. *International Source Book on Environmentally Sound Technologies for Municipal Solid Waste Management.* IECT Technical Publication Series 6, United Nations Environment Programme at http://www.unep.or.jp/ietc/ESTdir/Pub/MSW/index.asp

[35] Eunomia Research & Consulting (2008) *Queenstown Lakes District, Estimate of Home Composting Impact,* prepared for Queenstown Lakes District Council

[36] http://www.ccc.govt.nz/waste/composting/KitchenOrganicsTrial.asp

[37] Cameron L (2002), *Environmental Behaviours Through Community Interventions: A Case Study Of Waste Minimisation*. Report for Environment Waikato

compost their garden waste, with about three-quarters of those also putting food scraps in the compost.[38]

A 1996 compost bin trial by Manukau City Council included data from a survey conducted following a compost campaign in the city.[39] The proportion of regular composters was given as 30%, with an estimate that 55% of households are either active or potential composters.

In 2002, the Auckland Regional Council surveyed households to gather baseline data for a major regional environmental campaign. The survey found that 45% of those surveyed reported composting their household and garden waste "at every opportunity". A further 11%-15% do it "a lot of the time".[40]

The validity of these survey results is the matter of some dispute. Telephone surveys can not be considered totally reliable as the respondents may be providing what they perceive as the "right" answer. Estimates produced by Living Earth Ltd in conjunction with the Greenwaste Recyclers Organisation suggest that about seven percent of residences "*actively composted as opposed to heaping greenwaste in the back garden*".[41]

4.2 Nutrients in compost [42]

The composting process removes nutrients from the material being processed, and as a result, stabilised compost is a dilute fertiliser, with a typical analysis being about 1-1-1 (N-P_2O_5-K_2O). While composts have low levels of nutrients compared to fertilisers, they are often adequate for use in home gardens and sports fields, but not sufficient for use on agricultural or horticultural sites where plant and soil needs are greater.

The nitrogen content of compost varies according to the source material. Nitrogen in finished compost is primarily not readily available for plant absorption, being incorporated into organic compounds that resist decay. Similarly, much of the phosphorus in compost is incorporated in organic matter and not readily available to plants. As the phosphorus-containing organic matter decays, the phosphorus then binds readily with other elements in the soil, remaining unavailable. Potassium in compost is more readily available to plants than nitrogen or phosphorus, but leaches quickly from the soil as it is water soluble.

4.3 Organic material in soil [43]

Organic material is present in soil in a range of forms including living organisms, dead and decaying plant and animal remains, and the dark-coloured amorphous material referred to as "humus". Some of the carbon in soils is readily decomposable, and provides a short-term supply of energy for the soil micro-organisms. Other forms of carbon decompose much more slowly, and, while still providing an energy source for microbes, are more important for the improvement to soil properties. Another component of soil carbon is highly resistant to oxidisation and may remain in the soil for centuries, acting as a binding agent for soil particles.

[38] Dodd, J and Hall, D (1996) *Garden and Paper Waste Disposal in the Greater Auckland region*, A report prepared for councils within the Auckland region and Carter Holt Harvey by Research Solutions
[39] Ranacou, E (1996) *Report on the Compost Bin Trial Conducted in Manukau City, Using the Earthmaker Compost Bin*. Report prepared for Manukau City Council
[40] Research Solutions Ltd (2002) *Benchmark Study for "The Big Clean Up. Join In"*, prepared for the Auckland Regional Council
[41] Dave Perkins, General Manager, Living Earth Ltd, personal communication
[42] Mangan, F *et al* (undated) *Compost use and soil fertility*. Online at www.umassvegetable.org/soil_crop_pest_mgt/soil_nutrient_mgt/compost_use_soil_fertility.pdf -
[43] Much of this section has been adapted from Waste Not Consulting (2002) *Assessment of Options for the Management of Organic Kitchen Waste*, prepared for the Organic Waste Working Group of the Auckland Region Waste Managers Forum

Most plant and animal matter decomposes under aerobic conditions, breaking down the organic molecules and releasing the constituent carbon into the atmosphere as carbon dioxide. However, not all organic compounds are readily converted to carbon dioxide, even under aerobic conditions. Humus is the very stable form of organic matter that remains when most of the plant and animal residues in a soil have been decomposed by micro-organisms.[44] Humus is produced by the actions of a wide range of organisms, such as earthworms, insects, and bacteria, present in the soil.

Humus in soil makes the difference between a fertile growing environment and an inert mass of rock dust. The decomposing of organic compounds not only releases nutrients essential for plant growth, but alters the physical structure of the soil itself. The presence of humus improves the physical properties of the soil, creating the pore system which allows roots to grow and supplies the air and water which roots need to function.

Although humus itself will slowly decompose over time, in undisturbed soils the rate of humus production will eventually stabilise to equal the rate of humus decomposition. However, the quantity of organic matter in soil is influenced by both land usage and land management.

In most conditions, organic matter accumulates under grazed pastures and decreases under crops.[45] Soil under permanent pasture and grazing generally has excellent structure, a high content of organic matter, large numbers of earthworms, and is therefore very fertile. By contrast, soils used for vegetables and arable crops are often subject to intensive cultivation with little or no fallow period and therefore have poor structure, are susceptible to erosion and nutrient run-off, contain very little organic matter, and have low levels of earthworm activity.

For example, the Pukekohe region is the main vegetable growing area in the Auckland region. A study by Crop and Food Research soil scientists compared the quality of soil in Pukekohe under a pasture regime compared to soil under intensive cultivation. The study showed that the organic matter content of soil used for vegetable production had declined to about one-third that of permanent pasture.[46] This decline in organic matter was shown to adversely affect earthworm numbers, stability of soil aggregates, and total porosity of soil clods.

The addition of compost to soils that are intensively cultivated can reverse these effects. As well as improving the soil's properties of aggregation and plasticity, the addition of organic matter in the form of compost improves plant growth by:[47,48]

- Improving water-holding capacity of the soil – humic substances can hold up to five times their weight in water
- Increasing drainage – the large pores that are created between the aggregates formed by organic matter improve the drainage of the soil
- Improving heat absorption – the dark colouration of the humus raises soil temperatures by increasing the absorption of solar radiation
- Deactivating organic chemicals – organic chemicals, particularly herbicides, are deactivated on adsorption sites provided by humus
- Improving biological properties of soils by promoting activity of beneficial micro-organisms, reducing attacks by parasites, and promoting faster root development.

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[44] Cornforth, I. (1998) *Practical Soil Management*, Lincoln University Press, Canterbury
[45] Cornforth, I. (1998) *Practical Soil Management*, Lincoln University Press, Canterbury
[46] Haynes, R and Tregurtha, D (1999) *Effects of increasing periods under intensive arable vegetable production on biological, chemical and physical indices of soil quality*, Crop and Food Research, Auckland as cited by George Fietje, Living Earth Company, personal communication
[47] McLaren, R. and Cameron K. (1996) *Soil Science - Sustainable Production and Environmental Protection*, Oxford University Press, New Zealand
[48] USEPA (1999) *Organic Materials Management Strategies* EPA530R-99-016. Online at http://www.epa.gov/epaoswer/non-hw/compost/omms.pdf

4.4 Landfilling of organic household waste compared to home composting

When organic household waste is landfilled there are numerous disadvantages compared to the alternative of home composting. With regards to soil fertility, the major negative environmental effect of landfilling is the loss of nutrients and organic matter that could be returned to soils. When organic wastes are landfilled, the overall beneficial properties that organic wastes offer to soils are permanently locked away.

As a result, as soils are depleted there becomes a greater need to use more man-made fertilisers and non-renewable organic materials, such as peat, to improve the physical, biological, and chemical properties of soils, particularly those used for agricultural and horticultural purposes.

Home composting, however, does not necessarily lead to the improvements of the soils that need it the most. In most cases, households purchase commercially-grown food, compost the waste, and apply the resulting compost to their own property. This process results in the improvement of the householders' soils, but also results in the depletion of soils used for commercial growing purposes. In this instance, home composting does not 'close the loop'.

The overall environmental effect of home composting may be positive, but home composting does not address the problem of the degradation of soils used for agricultural and horticultural purposes. In this regard, centralised composting operations may be environmentally superior to home composting, particularly if the compost from large-scale composting operations is used by commercial growers.

5 Wasted food

Research into the potential for reducing avoidable food waste is relatively recent and, by necessity, methodologically complex. As in most matters related to waste, there are no standardised protocols for defining or quantifying food that is wasted, so it is not possible to directly compare the results of different studies. The results of several studies are summarised in the sections that follow.

5.1 WRAP – The food we waste

The UK government-funded organisation WRAP (Waste & Resources Action Programme) published a report in 2008 entitled '*The food we waste*'.[49] This report showed that one-third of all food purchased in the UK is disposed of without being eaten. The study also found that most of the food wastage by UK households was avoidable and 61% of the food that was wasted could have been eaten had it been better managed (e.g. left-over takeaways, food that has past its expiry-date). According to the research, about 115 kg of food per person is wasted each year, 70 kg of which could have been avoided. This figure includes all types of waste disposal, including landfills and composting.

'Truly unavoidable' food waste, like vegetable peelings, meat bones and carcasses, tea bags, coffee-grounds etc, accounted for 19% of the total food waste and the remaining 20% was classified as 'possibly avoidable' food waste, such as bread crusts or potato skins that do not necessarily need to be discarded if the food is prepared in specific ways. Over one-quarter of the avoidable food waste thrown away each year is either whole or still in its unopened packaging.

The top ten types of avoidable food waste, as a percentage of all avoidable food waste, were found to be:
1. Potatoes
2. Bread slices
3. Apples
4. Meat or fish mixed meals
5. World breads (e.g. naan, tortilla)
6. Vegetable mixed meals
7. Pasta mixed meals
8. Bread rolls/baguettes
9. Rice mixed meals
10. Mixed meals

5.2 Prudential UK – The Soggy Lettuce Report

An earlier UK study, completed in 2004, by insurance and investment firm Prudential found more money is wasted on food each year in the UK than any other category of goods or services – "a whopping £424 per person" per year.[50] In this report, a "shopping list of shame" revealed that over half of the 1000 people interviewed discarded lettuce, bags of salad, loaves of bread and fruit every week. Other items that were commonly discarded were milk, cooked meat, biscuits, and wine.

[49] WRAP (2008). *The food we waste*. Available online at www.wrap.org.uk/thefoodwewaste
[50] Prudential (2004). *The Soggy Lettuce Report*. Online at www.recycleforgloucestershire.com/shopsmart/assets/soggy_lettuce_pru.pdf

5.3 Timothy Jones - Using Contemporary Archaeology and Applied Anthropology to Understand Food Loss in the American Food System

This study by the United States Department of Agriculture sought to quantify food losses throughout the marketing system – from harvesting and processing through to retail distribution and the household.[51]

Household food loss was estimated to be 82 kg per person per annum. This total consisted of the following foods:

1. Grain 20%
2. Meat 11%
3. Fruit 16%
4. Vegetables 27%
5. Fats 2%
6. Liquid 5%
7. Slop 4%
8. Other 13%

Of this total, about 14% was packaged edible food (food that had not been taken out of its original packaging and was not out of date).

5.4 Waste Not Consulting Ltd – unpublished SWAP research

To provide local data on the quantity of food wasted by New Zealand's households, in December 2008 Waste Not conducted a brief analysis as part of a regular domestic waste audit conducted for a local authority in the Auckland region. The audit involved sorting domestic kerbside refuse into 31 categories, including two separate categories for kitchen waste: 1) food waste (including waste from preparing food and spoilt food) and 2) 'wasted food' (defined as being food that, were it not for being in the refuse bin, could otherwise have been eaten).

Results showed that 24% of the kitchen waste could have been eaten and was therefore classified as 'wasted food'. As kitchen waste comprised 42% of the total refuse, by weight, wasted food represented 10% of the total domestic kerbside refuse set out by households. This equated to approximately 0.95 kg every time a household sets out domestic kerbside refuse for collection.

Although specific data were not recorded, it appeared to the staff involved in the waste audit that bread was the most frequently wasted food item.

[51] T W Jones, (undated), *Using Contemporary Archaeology and Applied Anthropology to Understand Food Loss in the American Food System,* Online at http://www.communitycompost.org/info/usafood.pdf

Appendix 1 – References for waste calculations

	Report prepared for:	Date	Author/Name of report
Ref. 1	Auckland City Council	Dec-08	Waste Not Consulting Ltd *Auckland Isthmus Solid Waste Analysis - December 2008*
Ref. 2	Christchurch City Council	Jun-05	AgFirst Consultants *Analysis of the Christchurch Mixed Municipal Waste Stream 1 July 2003 to 30 June 2004*
Ref. 3	Franklin District Council	Feb-08	Waste Not Consulting Ltd *Analysis of Franklin District Domestic Kerbside Refuse*
Ref. 4	Hamilton City Council	Jun-03	Waste Not Consulting Ltd *Environment Waikato - Solid Waste Audits*
Ref. 5	Hastings District Council and Napier City Council	Jul-07	Waste Not Consulting Ltd *Survey of Solid Waste in Hawke's Bay*
Ref. 6	Manukau City Council	Oct-08	Waste Not Consulting Ltd *Analysis of Manukau City Domestic Kerbside Refuse*
Ref. 7	North Shore City Council	Aug-06	Waste Not Consulting Ltd *North Shore City Domestic Kerbside Bagged Refuse Analysis - August 2006*
Ref. 8	Papakura District Council	Oct-07	Waste Not Consulting Ltd *Analysis of domestic kerbside refuse in Papakura District*
Ref. 9	Rodney District Council	Dec-05	Waste Not Consulting Ltd *Analysis of Domestic Kerbside Refuse in Rodney District*
Ref. 10	Rotorua District Council	Aug-08	Waste Not Consulting Ltd *Analysis of Domestic Kerbside Refuse in Rotorua*
Ref. 11	Waitakere City Council	Sep-08	Waste Not Consulting Ltd *Surveys of Solid Waste in Waitakere City*
Ref. 12	Whakatane District Council	Dec-07	Waste Not Consulting Ltd *Surveys of Solid Waste to Whakatane Landfill*
Ref. 13	Whangarei District Council	Jun-08	Waste Not Consulting Ltd *Surveys of Solid Waste in Whangarei District*
Ref. 14	Ministry for the Environment	Oct-08	Waste Not Consulting Ltd *Solid Waste Audits for Ministry for the Environment Baseline Data Programme 2007 – 08 Volume 3 - Silverstream Landfill*
Ref. 15	Waitaki District Council	Dec-08	Waste Not Consulting Ltd *Analysis of Solid Waste at Oamaru Landfill*
Ref. 16	Taupo District Council	Mar-08	Waste Not Consulting Ltd *Analysis of residual waste to landfill at Broadlands Rd Resource Recovery Centre*
Ref. 17	Rotorua District Council	Oct-07	Waste Not Consulting Ltd *Rotorua District Landfill Solid Waste Analysis*
Ref. 18	Queenstown-Lakes District Council	Oct-08	Waste Not Consulting Ltd *Analysis of Solid Waste in Queenstown Lakes District*
Ref. 19	Southland WasteNet Councils	May-08	Waste Not Consulting Ltd *Solid Waste in Southland 2007*
Ref. 20	Auckland City Council	July-07	Waste Not Consulting Ltd *Analysis of Auckland City Inorganic Refuse Collection*
Ref. 21	Waitakere City Council	Feb-08	Waste Not Consulting Ltd *Analysis of Waitakere City Refuse*
Ref. 22	Matamata-Piako District Council and Environment Waikato	Mar-07	Waste Not Consulting Ltd *Survey of Waste Streams in Matamata-Piako District*
Ref. 23	Hauraki District Council and Environment Waikato	Apr-07	Waste Not Consulting Ltd *Analysis of Solid Waste Streams in Hauraki District*

Appendix 2 – Domestic kerbside refuse collections

Primary category	Secondary category	% of total	Wt per capita per annum
Paper	Recyclable	11.8%	18.1 kg
	Multimaterial/other	2.5%	3.8 kg
	Subtotal	**14.3%**	**21.9 kg**
Plastics	#1-7 packaging	2.9%	4.4 kg
	Plastic bags and film	7.0%	10.8 kg
	Multimaterial/other	2.2%	3.3 kg
	Subtotal	**12.1%**	**18.6 kg**
Putrescibles	Kitchen waste	40.0%	61.2 kg
	Greenwaste	9.6%	14.7 kg
	Subtotal	**49.6%**	**75.9 kg**
Ferrous metals	Steel cans	1.4%	2.1 kg
	Multimaterial/other	0.7%	1.1 kg
	Subtotal	**2.1%**	**3.2 kg**
Non-ferrous metals	Aluminium cans	0.3%	0.4 kg
	Multimaterial/other	0.6%	1.0 kg
	Subtotal	**0.9%**	**1.4 kg**
Glass	Bottles/jars	2.5%	3.8 kg
	Multimaterial/other	0.5%	0.8 kg
	Subtotal	**3.0%**	**4.6 kg**
Textiles		**3.8%**	**5.8 kg**
Nappies and sanitary		**10.7%**	**16.3 kg**
Rubble		**1.6%**	**2.5 kg**
Timber		**0.7%**	**1.1 kg**
Rubber		**0.2%**	**0.4 kg**
Potentially hazardous		**1.0%**	**1.5 kg**
TOTAL		**100.0%**	**153.1 kg**

Appendix 3 – Environmental effects of food waste disposers [52]

Food waste disposers are electric motor-driven appliances that are installed beneath domestic sinks. Food waste is ground up by the devices to a sufficiently small particle size that it can be transported through the domestic plumbing and reticulated sewerage system with the other household sewage. Manufacturers recommend that water be used to flush the ground food waste while the appliance is running.

A life cycle assessment of in-sink food waste disposal units would need to include:

- Energy and materials used during manufacture of the appliance
- Energy consumption of the appliance during operation
- Water consumption of the appliance during operation
- Energy consumption for transport of the sewage
- Energy consumption for supplying the water
- Effects on the sewerage system, including overflows
- Effects on the treatment plant
- .Effects related to final use or disposal of the sewage sludge.

The transport of food waste to treatment through a sewerage system is, superficially at least, a very efficient method of disposing of food waste as it involves no vehicular transport and is accomplished using an electric pumping system and gravity flow. However, some of these efficiencies are lost as the weight of the water used while operating the appliance can be ten to twenty times the weight of the food waste being disposed of.

The environmental effects of food waste disposers on sewerage systems seem to have been in dispute for almost as long as the appliances have been marketed. The home garbage grinder (as it was then called) was invented in the mid-1930s by a Wisconsin architect. Mass marketing of the devices did not begin until the late 1940s, and most major municipalities in the USA immediately responded by placing bans on their use.[53]

The claims against the use of food waste disposers that led to the bans include:[54]

- Clogging of indoor sewerage pipes
- Increased hydraulic flow within the sewerage reticulation system
- Increase in hydrogen sulphide in sewerage system due to the increase in readily biodegradable organics. As well as being a health and safety issue, this would reduce the pH of the sewage wastewater and increase corrosion of a sewerage reticulation system.
- Potential increase in incidence of sewer overflow
- Overloading of sewage treatment works
- Discharge of large quantities of nitrogen and phosphorus into waterways
- Increased cost of sewerage maintenance and wastewater treatment.

[52] This section has been adapted from Waste Not Consulting (2002) *Assessment of Options for the Management of Organic Kitchen Waste*, prepared for the Organic Waste Working Group of the Auckland Region Waste Managers Forum

[53] PHCC Educational Foundation (undated) *Food Waste Disposers: An Effective Home Waste Management System,* National Association of Plumbing, Heating, and Cooling Contractors, Falls Church Virginia

[54] Wong, P and Scott, E (2001) Report dated 26 July 2001 from the Director, Planning and Environmental Services about the *Assessment of Food Disposal Options in Multi unit Dwellings in Sydney*

These claims have been investigated extensively in a number of locations, particularly in New York City, where there was a ban on their use in combined sewer areas in place from the mid-1970s. A study for the city in 1991, based on a wide range of other research, characterised the effects of food waste disposers as being:[55]

- Effluent in a finely ground (<2 mm) flocculent condition that resists settling or sewer blockages
- Production of a material very similar to normal sewage with slightly higher volatile matter and much lower nitrogen content
- Addition of 20 grams/person/day of biological oxygen demand (BOD) (on average, each person produces a discharge of 77 grams/person/day of BOD without food waste disposers)
- Addition of 27 grams/person/day of suspended solids/person/day (on average, each person produces a discharge of 91 grams/person/day of suspended solids without food waste disposers)
- An additional water consumption of 10 litres per day for the average household (an increase of 2.6% of total daily household water use).

Pilot trials in New York conducted in 1996 found that the introduction of food waste disposers leads to an increase in water consumption of roughly 4 litres per capita per day and an increase in suspended solids and oils and grease of about 20% per capita for domestic wastewater [56] The impact of these increases was found to be only minor on sewers and wastewater treatment plants, water rates and consumption, and other environmental, public health and safety issues and the ban on food waste disposal units in combined sewer areas was lifted in 1997.

A Dutch study found that, with a five-ten percent market penetration of food waste disposers:

- There was no evidence that use of the devices leads to clogging of indoor or outdoor pipes
- The increase of loads to biological wastewater treatment processes is negligible
- There is an increase of 2.5% to 5% in loads to the sludge thickeners and digesters, equipment that dry and stabilise the resulting sewage sludge.[57]

The Waverley, New South Wales, local government considered research on the issue58 in 2000 and reported that a 50% market penetration would:[59]

- Increase water usage 6.2 litres/household/day
- Result in an additional 15% suspended solids and 33% BOD increase to effluent from the primary treatment plant
- Increase hydrogen sulphide within the sewerage system by 30%
- Exceed the existing peak capacity of the sewage treatment plant and result in sewer overflows.

On the basis of these findings, it was recommended to the council that bans on the installation of in-sink waste disposal devices in multi-unit housing remain. The council's sewage system relies upon the well-publicised Bondi outfall for disposal into the marine environment.

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[55] Pressman, W (1991) Kitchen garbage grinders in municipalities: An information manual as cited in PHCC Educational Foundation (undated) *Food Waste Disposers: An Effective Home Waste Management System*, National Association of Plumbing, Heating, and Cooling Contractors, Falls Church Virginia

[56] New York City Department of Environmental Protection (undated) *The Impact of Food Waste Disposers in Combined Sewer Areas of New York City* at www.ci.nyc.ny.us/html/dep/html/grinders.html

[57] de Koning, J (1996) *Kitchen Food Waste Disposers: Effects on Sewer System and Wastewater Treatment*, Technische Universiteit Delft, Department of Water Management, Environmental, and Sanitary Engineering at http://www.insinkerator.com/pdf/delpht.pdf

[58] www.crcwmpc.com.au/Publications/FoodWasteDisposalReport/FoodWasteDisposalReport.pdf

[59] Wong, P and Scott, E (2001) Report dated 26 July 2001 from the Director, Planning and Environmental Services about the Assessment of Food Disposal Options in Multi unit Dwellings in Sydney

Several studies publicised by the American plumbing industry association found that the suspended solids and BOD actually decreased in neighbourhoods when food waste disposal units were installed and that other household activities have a greater impact on wastewater characteristics than use of the units.[60]

In general, it is agreed that food waste disposers increase both household water usage and the suspended solids and BOD loading of the domestic wastewater. Whether or not these effects are problematic is dependent upon the receiving environment for the household discharges.

In sewerage systems, especially combined systems that are working at close to capacity such as those in Sydney and New York, the increased loadings are thought to be capable of increasing the frequency and volume of sewage overflows. For adequately-sized sewerage systems, the effects of food waste disposers are considered to be minimal.

In a similar manner, the effect of the increased sewage loading on wastewater treatment plants depends on the ability of the plant to properly treat a marginally increased loading. In a properly-designed facility with an excess of capacity, there should be only minimal effects from an increase market penetration of food waste disposers.

Other negative environmental effects which should be taken into account include the increased household water usage and consumption of electricity. In relation to overall household consumption of water and electricity, the increase is measurable but not substantial.

Positive environmental effects are also claimed for the use of food waste disposers. These include:

- Reduction of solid waste to landfill (unless the sewage sludge is landfilled)
- Reduction of odours, flies and vermin within the household environment due to reduced need for storage of putrescible materials in the home
- Increased organic carbon to wastewater treatment results in a greater quantity of biosolids being produced. The greater the quantity of biomass produced, the greater the amount of nutrients (nitrogen and phosphorus) locked up in the biomass and removed from the wastewater treatment effluent.[61]

In 2007, a major study of food waste disposers was undertaken by MWH for Parex Industries Ltd, local distributors of InSinkErator brand disposers.[62]. The key findings of the study are:

> • *on-site home composting is the optimal solution in many but not all residential situations*
> • *off-site composting managed by local authorities has its place but is challenging to manage, e.g. physical contamination, participation uptake and the management of the treatment process so as to avoid adverse effects*
> • *there is a shortage of standardised data about KFW* (kitchen food waste) *and a need to improve the monitoring of organic wastestreams*
> • *there are some unfounded perceptions against FWD* (food waste disposer)
> • *there is no single, correct solution for the management of KFW and no simple guide as to when to use a FWD or not*

[60] PHCC Educational Foundation (undated) *Food Waste Disposers: An Effective Home Waste Management System*, National Association of Plumbing, Heating, and Cooling Contractors, Falls Church Virginia
[61] Strutz, WF (1998) *A Brief Summary and Interpretation of Key Points, Facts, and Conclusions for University of Wisconsin Study: "Life Cycle Comparison of Five Engineered Systems for Managing Food Waste"* at www.insinkerator.com/pdf/uwstudy.pdf
[62] MWH, (2008), *Food Waste Management in New Zealand*, prepared for Parex Industries Ltd

• there are a number of drivers favouring the use of FWD (e.g. achieving New Zealand Waste Strategy target relating to the diversion of organic waste from landfill)
• there are situations where a municipal sewerage scheme is well suited to handle the extra load resulting from the use of the FWD and particularly if there are suitable biosolids disposal options
• processes which can benefit from the use of FWD as the KFW management option are mainly:
- Biological Nutrient Processes, which require carbon to remove nitrogen and phosphorus
- Anaerobic digestion, where biogas is utilised for energy generation
• enactment of the Waste Minimisation Bill with its provision of a waste levy may as a result stimulate considerable further investment in the kerbside collection of organic waste and associated downstream processes, and
• silo thinking of assessing options for managing KFW appears to have prevailed amongst decision makers.