APPENDIX I – Home Composting and Waste Management Questionnaires

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15 March 2004

Miss S Colston
45 Warwick Avenue
Egham
Surrey
TW20 8LW

Dear Miss Colston,

RUNNYMEDE HOME COMPOSTING AND HOUSEHOLD WASTE STUDY

Imperial College London is collaborating with Runnymede Borough Council on a research programme on home composting in your area. The research aims to evaluate the effectiveness of home composting as a method of diverting household waste from landfill disposal to help to protect the environment.

We understand from Runnymede Borough Council that you have purchased a home composting bin through their Home Composting Scheme. We are undertaking a survey of home composting in the Borough and to assist the research we ask if you would complete the short questionnaire enclosed and return it using the stamped addressed envelope provided.

To find out more about the research project visit the Imperial College website: http://ewre-www.cv.ic.ac.uk/personal/mitaftsi/research.htm.

Thank you for your assistance.

Yours sincerely,

Olympia Mitaftsi

Home Composting Questionnaire

Please tick the answers that are relevant to you

1. Do you own a composting bin?

Yes ☐

No ☐ *Please go to question 4*

2. How many composting bins do you have?

One ☐

Two ☐

Three ☐

Four ☐

If more than four, please state how many

……………………………………………..

3. Do you use your composting bin?

Yes ☐

No ☐

If no, please state why

…………………………………………………………………...

4. Do you participate in the Council's Kerbside Collection Scheme (Recycling Scheme)?

Yes ☐

No ☐

5. Do you take waste for disposal at a Civic Amenity site?

If yes, please specify which wastes and how often

………………………………..

How many bags approximately?

Less than one ☐

One ☐

Two ☐

3-5 ☐

6-8 ☐

If more than 8, please state how many

……………………………………...

6. Do you take waste to recycling banks?

If yes, please specify which wastes and how often

…………………………………….

How many boxes approximately?

Less than one ☐

One ☐

Two ☐

3-5 ☐

6-8 ☐

If more than 8, please state how many

……………………………………………...

7. **If you do not compost, would you consider starting composting at home[1]?**

Yes ☐

No ☐

If no, please state why

…………………………………………………………………

8. **How many people live in your household?**

One ☐

Two ☐

3-4 ☐

5-6 ☐

More than 6 ☐

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* Composting bins are available from Runnymede Borough Council at a subsidised price (£10 including delivery). Please contact the Recycling Manager at 01932 425713 for further information.

9. What is your employment status?

Fully employed ☐

Unemployed ☐

Home maker ☐

Retired ☐

10. Which type of property do you live in?

Detached house ☐

Semi-detached house ☐

Terrace house ☐

Bungalow ☐

Maisonette ☐

Cottage ☐

Flat ☐

11. Do you have access to any of the following?

Garden ☐

Shared garden ☐

Allotment ☐

Patio/Yard/Balcony ☐

Other…………………………………………………

12. What are the approximate dimensions of your garden?

Measurement in yards …………………………..

Measurement in metres……………………….....

Please provide us with your contact details as we may need to get in contact with you again about the research project.

Name:
Telephone number or Mobile:
E-mail:

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11 March 2004

Miss S Colston
45 Warwick Avenue
Egham
Surrey TW20 8LW

Dear Miss Colston,

RUNNYMEDE HOME COMPOSTING AND HOUSEHOLD WASTE STUDY

Imperial College is conducting a research programme on home composting and household waste management in your area in collaboration with Runnymede Borough Council. The aim of the research is to measure the effectiveness of home composting and other recyclate collection methods on diverting household waste from landfill disposal to help to protect the environment.

The purpose of this letter is to inform you of the Imperial College research programme (you can find more at the Imperial College website: http:// ewre-www.cv.ic.ac.uk / personal / mitaftsi / research.htm) and to request your assistance by completing the enclosed short questionnaire about how you dispose of or recycle your household waste. This information will help us to determine the effects of different methods of household waste management on the quantity of residual waste collected for landfill disposal.

This survey is important to improve waste management in the Borough of Runnymede and in the UK in general and we thank you for contributing by completing and returning the questionnaire.

Yours sincerely,

Olympia Mitaftsi

Waste Management Questionnaire

Please tick the answers that are relevant to you

1. **Do you participate in the Council's Kerbside Collection Scheme (Recycling Scheme)?**

   Yes ☐

   No ☐

2. **Do you take waste for disposal at a Civic Amenity site?**

If yes, please specify which wastes and how often

…………………………………..

How many bags approximately?

Less than one ☐

One ☐

Two ☐

3-5 ☐

6-8 ☐

If more than 8, please state how many

………………………………………………...

3. Do you take waste to recycling banks?

If yes, please specify which wastes and how often

……………………………………..

How many boxes approximately?

Less than one ☐

One ☐

Two ☐

3-5 ☐

6-8 ☐

If more than 8, please state how many

………………………………………………...

4. Do you compost waste at home?

Yes ☐

No ☐

5. If you <u>do not compost</u>, would you consider starting composting at home[2]?

Yes ☐

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* Composting bins are available from Runnymede Borough Council at a subsidised price (£10 including delivery). Please contact the Recycling Manager at 01932 425713 for further information.

No ☐

If no, please state why

……………………………………………………………………

6. How many people live in your household?

One ☐

Two ☐

3-4 ☐

5-6 ☐

More than 6 ☐

7. What is your employment status?

Fully employed ☐

Unemployed ☐

Home maker ☐

Retired ☐

8. Which type of property do you live in?

Detached house ☐

Semi-detached house ☐

Terrace house ☐

☐

Bungalow

Maisonette ☐

Cottage ☐

Flat ☐

9. Do you have access to any of the following?

Garden ☐

Shared garden ☐

Allotment ☐

Patio/Yard/Balcony ☐

Other…………………………………………………

10. What are the approximate dimensions of your garden?

Measurement in yards …………………………..

Measurement in metres………………………….....

Please provide us with your contact details as we may need to get in contact with you again about the research project.

Name:

Telephone number or Mobile:

E-mail:

APPENDIX II – Background to Waste Management in Runnymede Borough Council (RBC)

A2.1 Runnymede Borough Council
According to Census 2001 data, the resident population in Runnymede is 78,033 (National Statistics, 2004). The majority of residents are in the 30-59 age group (average age: 38.9 years) (41.8%), are married (49.3%) and fully employed (68.4%), and live in a semi-detached housing (33.6%).

A2.2 Household waste arisings in Runnymede
The amount of MSW collected by the Council in 2002/03 was 31,910 t and 85% (27,123.5 t) was household waste. Residual waste is collected from 32,206 properties; 75% of households dispose of waste in wheeled bins, 20% have multi-occupancy disposal systems and 0.5% use refuse bags.

A2.3 Household waste composition
A compositional analysis of household waste in RBC was commissioned in 2002 (MEL Research Ltd, 2004). Waste composition was tested during two seasons over four week periods in October 2002 and in February 2003, prior to the introduction of a kerbside collection (KC) scheme. On average households disposed of approximately 14 kg of waste per week. The selection of households was based on method of waste containment and socio-demographic profiles of the Districts and Boroughs using standard ACORN categories. Two categories were examined in Runnymede, including ACORN B (affluent executives/family areas, well-off workers/family areas) and ACORN E (new home owners/mature communities, white collar workers/better-off multi ethnic areas).

Putrescible waste was the largest single primary category in the residual waste and garden waste was present in all samples (Table A2.1). Approximately 70% of collected residual household waste was classified as biodegradable. Garden waste and kitchen compostable waste represented approximately 30% of total waste production and the disposal of compostable material was equivalent to 4 kg/hh/wk of. Paper and card were the next most prevalent primary waste category and households disposed of 2 kg/hh/wk of potentially recyclable paper and card.

Table A2.1 Average household waste composition in RBC

Primary category	October 2002		February 2003	
	ACORN B	ACORN E	ACORN B	ACORN E
Paper and card	29.36	15.31	26.36	22.64
Plastic film	5.02	3.47	4.04	4.86
Dense plastic	7.65	7.72	7.75	9.34
Textiles	4.56	3.72	1.93	3.64
Misc. Combustibles	6.89	4.26	8.35	5.59
Misc.non-combustibles	1.06	2.60	1.08	1.51
Glass	6.92	2.10	8.50	6.38
Ferrous metals	2.23	1.78	3.60	3.21
Non-ferrous metals	0.63	1.62	1.18	1.28
Putrescibles	31.87	51.12	32.73	38.44
Fines	6.46	5.64	3.02	2.73
WEEE	0.31	0.66	1.43	0.39
Hazardous	0.01	0.00	0.05	0.00
Total	100.00	100.00	100.00	100.00

A2.4 Management of household waste in Runnymede

A2.4.1 Total amounts of waste collected, recycled and composted

RBC is the waste collection authority and operates a weekly wheeled bin collection service. A weekly kerbside collection scheme was introduced in February 2003 and blue boxes were distributed for the collection of glass bottles, mixed cans and textiles; paper is collected in a blue bag, which is replaced after each collection. Kerbside collection is operated under contract. The total amounts of waste collected, recycled and composted in Runnymede during 2002/03 are listed in Table A2.2.

Table A2.2 Total amount of waste collected, recycled and composted in Runnymede Borough Council in 2002/03

Total waste collected (t)	31910
Total waste recycled (t)	1993.89
Recycling rate (%)	6.25
Paper (t)	1072.72
Glass (t)	811.37
Metals (t)	22.00
Textiles (t)	83.00
Total waste composted at home (t)	574.00
Home composting rate (%)	1.80

The Best Value Performance Indicator (BVPI) targets set for recycling in RBC are:

Year	**1998-1999**	**2003-2004**	**2005-2006**
Recycling/Composting Rate %	5	10	18

The current recycling rate in RBC (6.25 %) is below the BVPI.

A2.4.2 Recycling collection systems

Kerbside Collection

The number of households participating in the kerbside collection scheme is 22,031. The quantities of recyclable materials collected by the sheme and the proportion of each waste type are shown in Table A2.3.

Table A2.3 Kerbside collection of recyclable materials: types, tonnes and percentages

Type of recyclable material	**Amount collected by the kerbside scheme (t/wk)**	**Proportion of recyclable materials (% of collected waste)**
Glass – Green	33.09	12
- Brown	6.74	2
- Clear	23.77	9
Paper	176.72	64
Mixed cans	10.00	4
Scrap metal and white goods	4.80	2
Textiles	19.00	7
Total	**274.12**	**100**

Paper represented the largest recycled waste fraction equivalent to 64% of the total mass of material collected by the kerbside scheme, followed by glass which comprised 23% of the total. The recycling rate for paper in RBC is comparable with the national value for paper collection at the kerbside of 54% relative to other waste indicated by DEFRA statistics for 2002/03.

'Bring' recycling sites
There are 27 'bring' recycling sites located in the RBC area, including those operated at civic amenity sites, which collect the recyclable materials noted in Table A2.4

Table A2.4 Collection of recyclable materials at 'Bring' sites: types, tonnes and percentages

Type of Recyclable Material	Weight ($t\ y^{-1}$)	% of total waste collected at 'Bring' sites	No. of 'Bring' sites
Glass – Green	427.26	25.0	23
- Brown	90.89	5.3	23
- Clear	229.62	13.0	23
Paper	896.00	52.0	15
Mixed cans	12.00	0.7	11
Textiles	64.00	4.0	9
Total	**1719.77**	**100**	**-**

Similar patterns to KC were observed in the collection of recyclables at 'bring' sites. Paper represented the largest proportion of waste collected at bring sites equivalent to 52% of the total amount of recycled waste, followed by glass, which was 43.3% of the total recycled material.

Civic amenity sites
The civic amenity site operated by Surrey County Council serving residents in the Borough of Runnymede is at Lyne Lane, Chertsey. The site accepts bulk household waste, including furniture and electrical appliances (white goods), garden waste, cardboard, waste oil etc (RBC Online, 2004). The waste arisings at Lyne Lane during 2003 was 8,700 t from which 2,500 t were recyclables and 1,600 t were green waste.

A2.4.3 Composting
Runnymede Borough Council promotes HC through subsidised composting bin schemes. The total number of HC bins distributed in the area distributed through various distribution campaigns is 5,980.

APPENDIX III – Home Composting Leaflet

Troubleshooting

Problem	Cause	Solution
Odour	Inadequate aeration due to compaction or excess inputs of green waste	Mix and add brown waste
Wet and sodden	Too much green waste	Mix and add brown waste
Dry and twiggy	1. Not enough water 2. Too much brown waste	1. Water and mix 2. Add more green waste
Rodent attraction	1. Available food 2. Seeking warmth during winter 3. Open compost heap	1. Avoid adding meat or fish scraps 2. Mix and add brown waste to release heat 3. Use an enclosed compost bin
Not warming up	1. Too dry 2. Poor aeration 3. Insufficient nutrients	1. Water and mix, add more green waste 2. Mix and add more brown waste 3. Mix and add more green waste, e.g. grass clippings
Fruit flies	Exposed food waste	Cover food waste with leaves, grass, or a sheet of newspaper

Contact us

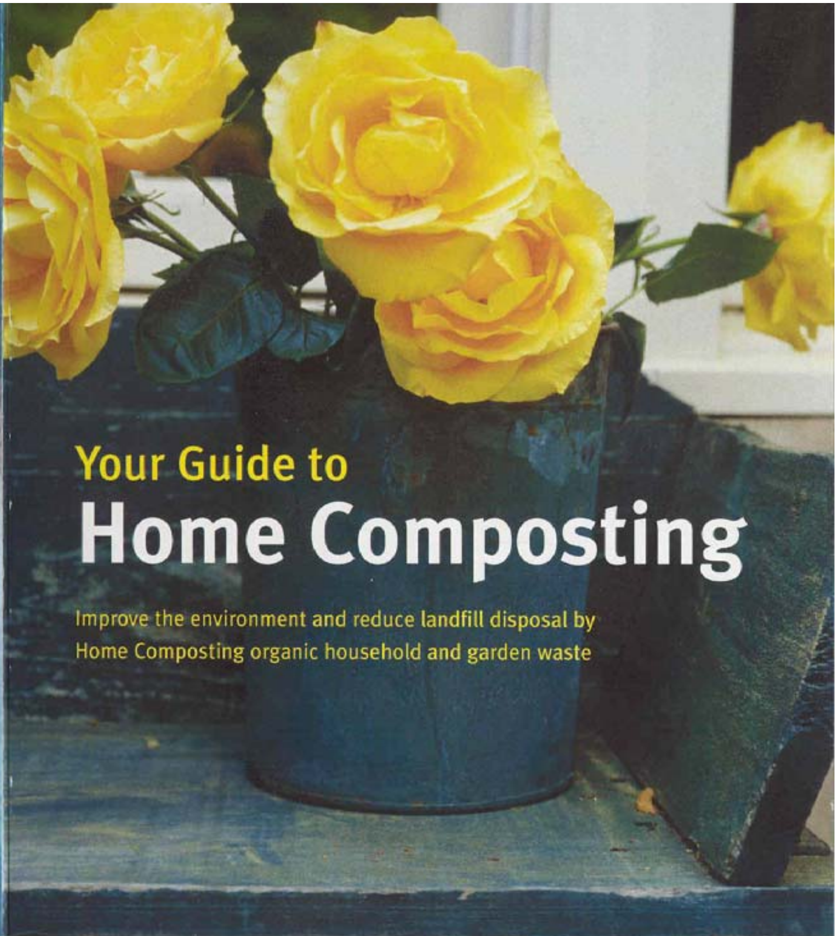
For more information on home composting and how to obtain a compost bin please contact **Mrs Maureen Chambers** at Runnymede Borough Council by telephone on **01932 425713** or visit the Council website: *www.runnymede.gov.uk/index_site.htm*

Information on the research project managed by Imperial College London can be found at the following website: *http://ewre-www.cv.ic.ac.uk/personal/mitaftsi/research.htm*

Imperial College London

THE NORLANDS foundation

RUNNYMEDE BOROUGH COUNCIL



Your Guide to
Home Composting

Improve the environment and reduce landfill disposal by Home Composting organic household and garden waste

Imperial College London

THE NORLANDS foundation

RUNNYMEDE BOROUGH COUNCIL

Your guide to home composting

Home composting reduces waste disposal in landfills

Organic waste in a composter

Waste converted to compost

Compost improves plant growth

What is Composting?

Composting is the natural breakdown of organic material and is carried out by micro-organisms like fungi and bacteria and by animals including worms, snails and insects. These organisms convert organic wastes into a rich, earthy end-product called compost that can be added to the garden to improve soil fertility and plant growth.

Why Composting?

- Organic household waste, like garden and kitchen waste, and waste paper and card, can be composted at home to produce a valuable soil conditioner that is an effective replacement for peat and artificial fertilisers for use in the garden.
- Composting diverts organic household waste from disposal in landfills and reduces the environmental damage caused by disposing of this type of waste in landfill, which is a major contributor to greenhouse gas emissions and water contamination.
- Composting is simple to do, it saves money and is rewarding, and also helps to protect the environment.

What to Compost at Home

Most kitchen, garden and paper waste can be composted. Suitable materials for home composting, and wastes that should not be placed in the compost bin, are listed in the table opposite.

What to compost at home...

	OK to put in the bin	Example
✓	Garden waste	Lawn clippings, leaves, green plant waste, shredded wood, finely chopped dry plant material
✓	Food leftovers	Cooked vegetables, eggshells, bread, cakes and pastries
✓	Kitchen and vegetable waste	Fruit and vegetable peel, fruit cores, vegetable stems and leaves, cut flowers
✓	Paper and card	Cut up boxes and cartons, paper tissue, waste paper, egg boxes, torn up toilet/kitchen roll tubes
✓	Waste from drink preparation	Coffee grounds and filters, tea bags

	Keep out of the bin	Example
✗	All liquids	Oil, milk, soups, juices
✗	Cooked and raw meat and bones	Red meat, pork, fish and poultry
✗	Plastic	Plastic wrappers, containers, lids and films
✗	Metal	Cans, tins, bottle tops, foil and staples
✗	Glass	Bottles and jars, broken glass
✗	Pet manure and litter	Domestic animal litter and waste
✗	Weeds	All weeds that have gone to seed
✗	Wood and twigs	Prunings. Unsuitable or excess garden waste should be taken for composting to a civic amenity site
✗	Recyclable paper	Magazines, directories, newspapers, glossy paper
✗	Bathroom waste	Nappies

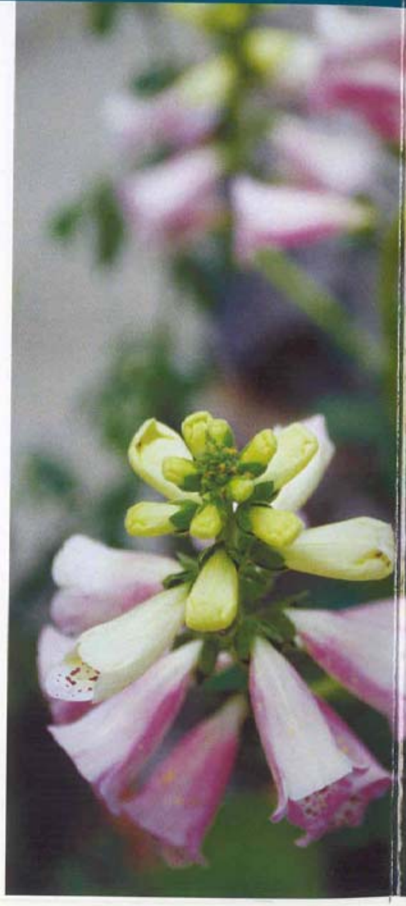
How to Compost

Successful home composting depends on getting the right balance between the brown and green waste fractions to ensure adequate nutrients, moisture content and aeration in the compost bin for microbial activity.

Brown Waste is dry fibrous waste that supplies carbon for microbial activity and provides structure and air spaces to promote microbial degradation. It consists of small shredded twigs and wood, paper and card, straw and brown leaves, etc.

Green Waste is soft organic material that has a high water content and provides moisture and nutrients, such as nitrogen, necessary for microbial development. It consists of grass clippings, kitchen and food waste.

Anyone can convert household waste into a rich organic soil conditioner by home composting



Research at Imperial College London has shown that home produced composts are more effective than peat at improving the growth of garden plants.

FIELD STUDY

Runnymede Home Composting Project

Measuring microbial activity in a home composter

Runnymede Borough Council, in conjunction with researchers at Imperial College London and the Norlands Foundation, has completed a 3-year study to measure the effectiveness of home composting in diverting organic household waste from landfill disposal.

A group of homeowners participated in the research and volunteered to compost their kitchen, garden and paper waste in composting bins provided at a subsidised cost by the Council.

This showed that the average household participating in the home composting scheme diverted 400 kg of organic waste per year from landfill disposal, representing a substantial contribution to the recycling of household waste in the Borough.

The research is continuing and will measure waste diversion by home composting and kerbside collection using specialised weighing equipment fitted to a refuse collection vehicle and electronic tags in the wheelie bins.

APPENDIX IV – Procedure for Fitting Microchips to Wheeled Bins

Equipment	Chipping Procedure
Micro-chips are delivered in separate bags. Bag content: 1 x Micro-chip 7 mm 1 x Bin sticker with Barcode (large) 1 x Allocation sticker (small) Mounting of the micro-chips: • Rubber mallet • Drilling template 7 mm • Drill 7 mm • Drill machine (battery) • Cloth • Laminate	Mounting of the transponder: 1. Open bin lid 2. Locate the drilling template front-left edge of the bin and hold it tight 3. Drill the hole through template 4. Use rubber mallet to drive micro-chip into the hole Fix the stickers: 1. Fix 'Bin sticker' in upper third of the left bin side. The area must be clean and dry by using a cloth. 2. The bin sticker is covered with a laminate. The bin sticker and the laminate are mounted without bubbles. 3. The 'Allocation sticker' is attached to the distribution list. The sticker contains bin information in the barcode.

APPENDIX V – Home Composting Database

Software Input Data								
Chip Code								
Contact details								
Name								
Surname								
House Name								
Address								
Post Code								
Tel number								
E-mail								
Treatment								
Treatment Group	Recycling Only	Recycling&Composting	Recycling&Composting&Leaflet	Recycling&Composting&Leaflet &Visits	Composting Only	Control		
Property characteristics								
Number of residents	1	2	3-4	5-6	>6			
Type of property	Detached	Semi-detatached	Terrace	Bungalow	Maisonnaite	Cottage	Flat	
Type of garden	Garden	Shared garden	Allotment	Patio/Yard/Balcony	Other			
Garden dimensions	Very Large	Large	Medium	Small	Very Small			
Employment								
Employment Status	Fully employed	Part time employed	Unemployed	Home maker	Retired			
Area								
Street name	Ambleside Way	Ashleigh Avenue	Ayebridges Avenue	Barons Way	Bishops Way	Borrowdale Close	Boscombe Close	Buttermere Way
	Clandon Avenue	Clockhouse Lane East	Coniston Way	Crossways	Derwent Road	Grasmere Close	Helvellyn Close	Huntingfield Way
	Keswick Road	Knights Close	Lacey Close	Langton Way	Longside Close	Malet Close	Oak Avenue	Park Avenue
	Rydal Way	South Avenue	Stephen Close	The Lea	Thirlmere Close	Thorpe Lea Road	Warwick Avenue	Wavendene Avenue
	Windermere Close							
Waste disposal								
Have a home composter	NO							
	YES							
	No. of composters	1	2	3	4	5	6	>6
Participation in kerbside collection?	NO							
	YES							
Disposal to CA sites?	NO							
	YES							
	Frequency	Low	Medium	High				
Disposal to Recycling Banks?	NO							
	YES							
	Frequency	Low	Medium	High				
Time								
Week from commencement	Select individual week number, i.e. individually calculate date from start							

Monthly from commencement	Same as with week from commencement							
Month quarter intervals	**Jan-Mar**	**Apr-Jun**	**Jul-Sept**	**Oct-Dec**				
Season	**Winter (21/12-20/3)**	**Spring (21/3-20/6)**	**Summer (21/6-20/9)**	**Autumn (21/9-20/12)**				
Year	**1st**	**2nd**						
Bin type and number								
Number of wheelie bins	1	2	3					
Wheelie Bin	**Capacity**							
	240 l	120 l						
Home Composter	**Capacity**							
	290 lt	330 lt	DIY					

APPENDIX VI – Waste Compositional Analysis

Table A6.1 Waste analysis data for 'Control' households – June 2004

Sample size: 17 households

Materials	Collected as refuse (kg)	Arisings kg/hhld/wk	Arisings summary kg/hhld/wk	Assay of Arisings wt %	Assay summary wt %	Potential recyclables kg/hhld/wk	P. recyclables summary kg/hhld/wk	Potential recyclables wt %	P. recyclables summary wt %
Newspapers	9.43	0.55		4.46		0.55		4.46	
Magazines	4.71	0.28		2.23		0.28		2.23	
Recyclable Office Paper	3.04	0.18		1.44		0.18		1.44	
Cardboard Boxes/Containers	11.44	0.67	2.73	5.41	21.97	0.67	2.37	5.41	19.05
Multi-Layer Packaging	1.84	0.11		0.87		-		-	
Other Paper and Card	11.64	0.68		5.51		0.68		5.51	
Non-recyclable Paper	4.34	0.26		2.05		-		-	
Refuse Sack and Carrier Bags	4.28	0.25		2.03		-		-	
Packaging Film	3.8	0.22	0.49	1.80	3.92	-	0.00	-	0.00
Other Plastic Film	0.21	0.01		0.10		-		-	
PET Bottles, Clear	1.74	0.10		0.82		0.10		0.82	
PET Bottles, Coloured	0.68	0.04		0.32		0.04		0.32	
HDPE Bottles, Clear	1.46	0.09		0.69		0.09		0.69	
HDPE Bottles, Coloured	1.96	0.12		0.93		0.12		0.93	
PVC Bottes, Clear & Coloured	0.24	0.01	0.84	0.11	6.78	0.01	0.56	0.11	4.53
PP Bottles, Clear & Coloured	0.25	0.01		0.12		0.01		0.12	
Food Packaging	4.65	0.27		2.20		0.14		1.10	
Non-Food Packaging	1.84	0.11		0.87		0.05		0.44	
Other Dense Plastics	1.51	0.09		0.71		-		-	
Textiles	2.55	0.15	0.15	1.21	1.21	-	0.00	-	0.00
Shoes	1.74	0.10		0.82		-		-	
Disposable Nappies & San. towels	0	-		-		-		-	
Wood	0.69	0.04	0.60	0.33	4.86	-	0.00	-	0.00
Carpet and Underlay	0	-		-		-		-	
Furniture	0	-		-		-		-	
Other Misc. Combustible	7.85	0.46		3.71		-		-	
C & D Waste	0.01	0.00	0.01	0.00	0.11	-	0.00	-	0.00
Other MNC	0.23	0.01		0.11		-		-	
Packaging Glass	9.81	0.58	0.68	4.64	5.48	0.58	0.58	4.64	4.64
Non-Packaging Glass	1.78	0.10		0.84		-		-	
Food and Beverage cans	3.73	0.22	0.32	1.76	2.59	0.22	0.22	1.76	1.76
Other Ferrous Metals	1.74	0.10		0.82		-		-	
Food and Beverage cans	1.4	0.08		0.66		0.08		0.66	
Aluminium Foil	0.78	0.05	0.14	0.37	1.09	-	0.08	-	0.66
Other Non-Ferrous Metal	0.12	0.01		0.06		-		-	
Kitchen-Raw veggies + Peel	26.99	1.59		12.77		1.59		12.77	
Kitchen- Processed Food + meat	26.47	1.56		12.52		-		-	
Liquids	3.51	0.21	6.31	1.66	50.72	-	3.97	-	31.91
Garden Waste	40.46	2.38		19.14		2.38		19.14	
Other Putrescibles	9.77	0.57		4.62		-		-	
Lead/acid batteries	0	-		-		-		-	
Oil	0	-	0.05	-	0.38	-	0.00	-	0.00
Identifiable Clinical waste	0	-		-		-		-	
Other Potentially Hazardous	0.8	0.05		0.38		-		-	
White Goods	0	-		-		-		-	
Large Electronic Goods	0	-	0.02	-	0.18	-	0.00	-	0.00
TVs and Monitors	0	-		-		-		-	
Other WEEE	0.38	0.02		0.18		-		-	
Fines	1.48	0.09	0.09	0.70	0.70	-	-	-	-
Totals	211.35	12.43	12.43	100.00	100.00	7.78	7.78	62.56	62.56

Table A6.2 Waste analysis data for ‘Recycling only’ households – June 2004

Sample size: 50 households

<table>
<tr><th>Materials</th><th>Collected as refuse (kg)</th><th>Arisings kg/hhld/wk</th><th>Arisings summary kg/hhld/wk</th><th>Assay of Arisings wt %</th><th>Assay summary wt %</th><th>Potential recyclables kg/hhld/wk</th><th>P. recyclables summary kg/hhld/wk</th><th>Potential recyclables wt %</th><th>P. recyclables summary wt %</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Newspapers</td><td>26.78</td><td>0.54</td><td rowspan="7">2.97</td><td>3.20</td><td rowspan="7">17.77</td><td>0.54</td><td rowspan="7">2.57</td><td>3.20</td><td rowspan="7">15.35</td></tr>
<tr><td>Magazines</td><td>15.48</td><td>0.31</td><td>1.85</td><td>0.31</td><td>1.85</td></tr>
<tr><td>Recyclable Office Paper</td><td>8.02</td><td>0.16</td><td>0.96</td><td>0.16</td><td>0.96</td></tr>
<tr><td>Cardboard Boxes/Containers</td><td>42.61</td><td>0.85</td><td>5.10</td><td>0.85</td><td>5.10</td></tr>
<tr><td>Multi-Layer Packaging</td><td>5.14</td><td>0.10</td><td>0.61</td><td>-</td><td>-</td></tr>
<tr><td>Other Paper and Card</td><td>35.39</td><td>0.71</td><td>4.23</td><td>0.71</td><td>4.23</td></tr>
<tr><td>Non-recyclable Paper</td><td>15.15</td><td>0.30</td><td>1.81</td><td>-</td><td>-</td></tr>
<tr><td>Refuse Sack and Carrier Bags</td><td>12.32</td><td>0.25</td><td rowspan="3">0.59</td><td>1.47</td><td rowspan="3">3.55</td><td>-</td><td rowspan="3">0.00</td><td>-</td><td rowspan="3">0.00</td></tr>
<tr><td>Packaging Film</td><td>17.33</td><td>0.35</td><td>2.07</td><td>-</td><td>-</td></tr>
<tr><td>Other Plastic Film</td><td>0.01</td><td>0.00</td><td>0.00</td><td>-</td><td>-</td></tr>
<tr><td>PET Bottles, Clear</td><td>6.74</td><td>0.13</td><td rowspan="9">1.14</td><td>0.81</td><td rowspan="9">6.83</td><td>0.13</td><td rowspan="9">0.67</td><td>0.81</td><td rowspan="9">4.01</td></tr>
<tr><td>PET Bottles, Coloured</td><td>2.76</td><td>0.06</td><td>0.33</td><td>0.06</td><td>0.33</td></tr>
<tr><td>HDPE Bottles, Clear</td><td>5.55</td><td>0.11</td><td>0.66</td><td>0.11</td><td>0.66</td></tr>
<tr><td>HDPE Bottles, Coloured</td><td>3.74</td><td>0.07</td><td>0.45</td><td>0.07</td><td>0.45</td></tr>
<tr><td>PVC Bottes, Clear & Coloured</td><td>0.52</td><td>0.01</td><td>0.06</td><td>0.01</td><td>0.06</td></tr>
<tr><td>PP Bottles, Clear & Coloured</td><td>0.76</td><td>0.02</td><td>0.09</td><td>0.02</td><td>0.09</td></tr>
<tr><td>Food Packaging</td><td>19.97</td><td>0.40</td><td>2.39</td><td>0.20</td><td>1.19</td></tr>
<tr><td>Non-Food Packaging</td><td>6.91</td><td>0.14</td><td>0.83</td><td>0.07</td><td>0.41</td></tr>
<tr><td>Other Dense Plastics</td><td>10.15</td><td>0.20</td><td>1.21</td><td>-</td><td>-</td></tr>
<tr><td>Textiles</td><td>10</td><td>0.20</td><td>0.20</td><td>1.20</td><td>1.20</td><td>-</td><td>0.00</td><td>-</td><td>0.00</td></tr>
<tr><td>Shoes</td><td>2.9</td><td>0.06</td><td rowspan="6">1.14</td><td>0.35</td><td rowspan="6">6.84</td><td>-</td><td rowspan="6">0.00</td><td>-</td><td rowspan="6">0.00</td></tr>
<tr><td>Disposable Nappies & San. towels</td><td>28</td><td>0.56</td><td>3.35</td><td>-</td><td>-</td></tr>
<tr><td>Wood</td><td>2.8</td><td>0.06</td><td>0.33</td><td>-</td><td>-</td></tr>
<tr><td>Carpet and Underlay</td><td>2.08</td><td>0.04</td><td>0.25</td><td>-</td><td>-</td></tr>
<tr><td>Furniture</td><td>0</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Other Misc. Combustible</td><td>21.39</td><td>0.43</td><td>2.56</td><td>-</td><td>-</td></tr>
<tr><td>C & D Waste</td><td>4.21</td><td>0.08</td><td rowspan="2">0.19</td><td>0.50</td><td rowspan="2">1.13</td><td>-</td><td rowspan="2">0.00</td><td>-</td><td rowspan="2">0.00</td></tr>
<tr><td>Other MNC</td><td>5.23</td><td>0.10</td><td>0.63</td><td>-</td><td>-</td></tr>
<tr><td>Packaging Glass</td><td>35.07</td><td>0.70</td><td rowspan="2">0.91</td><td>4.20</td><td rowspan="2">5.45</td><td>0.70</td><td rowspan="2">0.70</td><td>4.20</td><td rowspan="2">4.20</td></tr>
<tr><td>Non-Packaging Glass</td><td>10.52</td><td>0.21</td><td>1.26</td><td>-</td><td>-</td></tr>
<tr><td>Food and Beverage cans</td><td>7.95</td><td>0.16</td><td rowspan="2">0.26</td><td>0.95</td><td rowspan="2">1.54</td><td>0.16</td><td rowspan="2">0.16</td><td>0.95</td><td rowspan="2">0.95</td></tr>
<tr><td>Other Ferrous Metals</td><td>4.91</td><td>0.10</td><td>0.59</td><td>-</td><td>-</td></tr>
<tr><td>Food and Beverage cans</td><td>2.9</td><td>0.06</td><td rowspan="3">0.22</td><td>0.35</td><td rowspan="3">1.33</td><td>0.06</td><td rowspan="3">0.06</td><td>0.35</td><td rowspan="3">0.35</td></tr>
<tr><td>Aluminium Foil</td><td>4.19</td><td>0.08</td><td>0.50</td><td>-</td><td>-</td></tr>
<tr><td>Other Non-Ferrous Metal</td><td>4.05</td><td>0.08</td><td>0.48</td><td>-</td><td>-</td></tr>
<tr><td>Kitchen-Raw veggies + Peel</td><td>109.89</td><td>2.20</td><td rowspan="5">8.81</td><td>13.15</td><td rowspan="5">52.72</td><td>2.20</td><td rowspan="5">5.86</td><td>13.15</td><td rowspan="5">35.03</td></tr>
<tr><td>Kitchen- Processed Food + meat</td><td>99.26</td><td>1.99</td><td>11.87</td><td>-</td><td>-</td></tr>
<tr><td>Liquids</td><td>8.25</td><td>0.17</td><td>0.99</td><td>-</td><td>-</td></tr>
<tr><td>Garden Waste</td><td>182.93</td><td>3.66</td><td>21.88</td><td>3.66</td><td>21.88</td></tr>
<tr><td>Other Putrescibles</td><td>40.36</td><td>0.81</td><td>4.83</td><td>-</td><td>-</td></tr>
<tr><td>Lead/acid batteries</td><td>0</td><td>-</td><td rowspan="4">0.02</td><td>-</td><td rowspan="4">0.10</td><td>-</td><td rowspan="4">0.00</td><td>-</td><td rowspan="4">0.00</td></tr>
<tr><td>Oil</td><td>0</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Identifiable Clinical waste</td><td>0.32</td><td>0.01</td><td>0.04</td><td>-</td><td>-</td></tr>
<tr><td>Other Potentially Hazardous</td><td>0.49</td><td>0.01</td><td>0.06</td><td>-</td><td>-</td></tr>
<tr><td>White Goods</td><td>0</td><td>-</td><td rowspan="4">0.04</td><td>-</td><td rowspan="4">0.26</td><td>-</td><td rowspan="4">0.00</td><td>-</td><td rowspan="4">0.00</td></tr>
<tr><td>Large Electronic Goods</td><td>0</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>TVs and Monitors</td><td>0</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Other WEEE</td><td>2.17</td><td>0.04</td><td>0.26</td><td>-</td><td>-</td></tr>
<tr><td>Fines</td><td>10.74</td><td>0.21</td><td>0.21</td><td>1.28</td><td>1.28</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>**Totals**</td><td>835.94</td><td>16.72</td><td>16.72</td><td>100.00</td><td>100.00</td><td>10.01</td><td>10.01</td><td>59.88</td><td>59.88</td></tr>
</table>

Table A6.3 Waste analysis data for Composting-only households - June 2004

Sample size: 12 households

Materials	Collected as refuse (kg)	Arisings kg/hhld/wk	Arisings summary kg/hhld/wk	Assay of Arisings wt %	Assay summary wt %	Potential recyclables kg/hhld/wk	P. recyclables summary kg/hhld/wk	Potential recyclables wt %	P. recyclables summary wt %
Newspapers	7.83	0.65		4.45		0.65		4.45	
Magazines	5.84	0.49		3.32		0.49		3.32	
Recyclable Office Paper	1.17	0.10		0.67		0.10		0.67	
Cardboard Boxes/Containers	6.89	0.57	3.05	3.92	20.77	0.57	2.61	3.92	17.81
Multi-Layer Packaging	1.06	0.09		0.60		-		-	
Other Paper and Card	9.6	0.80		5.46		0.80		5.46	
Non-recyclable Paper	4.15	0.35		2.36		-		-	
Refuse Sack and Carrier Bags	3.11	0.26		1.77		-		-	
Packaging Film	4.78	0.40	0.66	2.72	4.51	-	0.00	-	0.00
Other Plastic Film	0.04	0.00		0.02		-		-	
PET Bottles, Clear	1.14	0.10		0.65		0.10		0.65	
PET Bottles, Coloured	0.49	0.04		0.28		0.04		0.28	
HDPE Bottles, Clear	1.28	0.11		0.73		0.11		0.73	
HDPE Bottles, Coloured	0.46	0.04		0.26		0.04		0.26	
PVC Bottes, Clear & Coloured	0.03	0.00	0.81	0.02	5.51	0.00	0.51	0.02	3.47
PP Bottles, Clear & Coloured	0.1	0.01		0.06		0.01		0.06	
Food Packaging	3.76	0.31		2.14		0.16		1.07	
Non-Food Packaging	1.45	0.12		0.82		0.06		0.41	
Other Dense Plastics	0.98	0.08		0.56		-		-	
Textiles	0	-	0.00	-	0.00	-	0.00	-	0.00
Shoes	0	-		-		-		-	
Disposable Nappies & San. towels	10.91	0.91		6.20		-		-	
Wood	0.03	0.00	1.15	0.02	7.84	-	0.00	-	0.00
Carpet and Underlay	0	-		-		-		-	
Furniture	0	-		-		-		-	
Other Misc. Combustible	2.85	0.24		1.62		-		-	
C & D Waste	1.81	0.15	0.18	1.03	1.23	-	0.00	-	0.00
Other MNC	0.35	0.03		0.20		-		-	
Packaging Glass	11.81	0.98	1.02	6.71	6.95	0.98	0.98	6.71	6.71
Non-Packaging Glass	0.41	0.03		0.23		-		-	
Food and Beverage cans	2.04	0.17	0.23	1.16	1.53	0.17	0.17	1.16	1.16
Other Ferrous Metals	0.66	0.06		0.38		-		-	
Food and Beverage cans	0.75	0.06		0.43		0.06		0.43	
Aluminium Foil	0.47	0.04	0.13	0.27	0.86	-	0.06	-	0.43
Other Non-Ferrous Metal	0.3	0.03		0.17		-		-	
Kitchen-Raw veggies + Peel	15.31	1.28		8.70		1.28		8.70	
Kitchen- Processed Food + meat	15.92	1.33		9.05		-		-	
Liquids	0.11	0.01	7.26	0.06	49.51	-	5.87	-	40.04
Garden Waste	55.13	4.59		31.34		4.59		31.34	
Other Putrescibles	0.63	0.05		0.36		-		-	
Lead/acid batteries	0	-		-		-		-	
Oil	0	-	0.01	-	0.08	-	0.00	-	0.00
Identifiable Clinical waste	0.14	0.01		0.08		-		-	
Other Potentially Hazardous	0	-		-		-		-	
White Goods	0	-		-		-		-	
Large Electronic Goods	0	-	0.02	-	0.11	-	0.00	-	0.00
TVs and Monitors	0	-		-		-		-	
Other WEEE	0.2	0.02		0.11		-		-	
Fines	1.94	0.16	0.16	1.10	1.10	-	-	-	-
Totals	175.93	14.66	14.66	100.00	100.00	10.21	10.21	69.62	69.62

Table A6.4 Waste analysis data for 'Recycling and composting' households – June 2004

Sample size: 37 households

Materials	Collected as refuse (kg)	Arisings kg/hhld/wk	Arisings summary kg/hhld/wk	Assay of Arisings wt %	Assay summary wt %	Potential recyclables kg/hhld/wk	P. recyclables summary kg/hhld/wk	Potential recyclables wt %	P. recyclables summary wt %
Newspapers	6.59	0.18	2.83	1.27	20.21	0.18	2.29	1.27	16.33
Magazines	2.89	0.08		0.56		0.08		0.56	
Recyclable Office Paper	15.89	0.43		3.07		0.43		3.07	
Cardboard Boxes/Containers	24.22	0.65		4.68		0.65		4.68	
Multi-Layer Packaging	5.48	0.15		1.06		-		-	
Other Paper and Card	34.96	0.94		6.75		0.94		6.75	
Non-recyclable Paper	14.58	0.39		2.82		-		-	
Refuse Sack and Carrier Bags	7.63	0.21	0.55	1.47	3.92	-	0.00	-	0.00
Packaging Film	11.31	0.31		2.18		-		-	
Other Plastic Film	1.38	0.04		0.27		-		-	
PET Bottles, Clear	2.52	0.07	0.94	0.49	6.68	0.07	0.56	0.49	3.97
PET Bottles, Coloured	1.51	0.04		0.29		0.04		0.29	
HDPE Bottles, Clear	4.21	0.11		0.81		0.11		0.81	
HDPE Bottles, Coloured	2.76	0.07		0.53		0.07		0.53	
PVC Bottes, Clear & Coloured	0.15	0.00		0.03		0.00		0.03	
PP Bottles, Clear & Coloured	0.38	0.01		0.07		0.01		0.07	
Food Packaging	10.6	0.29		2.05		0.14		1.02	
Non-Food Packaging	7.42	0.20		1.43		0.10		0.72	
Other Dense Plastics	5.05	0.14		0.98		-		-	
Textiles	3.77	0.10	0.10	0.73	0.73	-	0.00	-	0.00
Shoes	1.97	0.05	0.75	0.38	5.33	-	0.00	-	0.00
Disposable Nappies & San. towels	9.4	0.25		1.82		-		-	
Wood	0.16	0.00		0.03		-		-	
Carpet and Underlay	2.7	0.07		0.52		-		-	
Furniture	0	-		-		-		-	
Other Misc. Combustible	13.35	0.36		2.58		-		-	
C & D Waste	44.94	1.21	1.27	8.68	9.06	-	0.00	-	0.00
Other MNC	1.97	0.05		0.38		-		-	
Packaging Glass	5.78	0.16	0.20	1.12	1.40	0.16	0.16	1.12	1.12
Non-Packaging Glass	1.49	0.04		0.29		-		-	
Food and Beverage cans	4.18	0.11	0.20	0.81	1.41	0.11	0.11	0.81	0.81
Other Ferrous Metals	3.1	0.08		0.60		-		-	
Food and Beverage cans	0.53	0.01	0.08	0.10	0.56	0.01	0.01	0.10	0.10
Aluminium Foil	0.96	0.03		0.19		-		-	
Other Non-Ferrous Metal	1.39	0.04		0.27		-		-	
Kitchen-Raw veggies + Peel	39.42	1.07	6.70	7.61	47.88	1.07	4.79	7.61	34.23
Kitchen- Processed Food + meat	40.58	1.10		7.84		-		-	
Liquids	17.06	0.46		3.30		-		-	
Garden Waste	137.77	3.72		26.61		3.72		26.61	
Other Putrescibles	13.07	0.35		2.52		-		-	
Lead/acid batteries	0	-	0.09	-	0.62	-	0.00	-	0.00
Oil	0	-		-		-		-	
Identifiable Clinical waste	0.34	0.01		0.07		-		-	
Other Potentially Hazardous	2.85	0.08		0.55		-		-	
White Goods	0	-	0.15	-	1.04	-	0.00	-	0.00
Large Electronic Goods	2.62	0.07		0.51		-		-	
TVs and Monitors	0	-		-		-		-	
Other WEEE	2.75	0.07		0.53		-		-	
Fines	6.04	0.16	0.16	1.17	1.17	-	-	-	-
Totals	517.72	13.99	13.99	100.00	100.00	7.91	7.91	56.55	56.55

Table A6.5 Waste analysis data for ‘Control’ households – Nov 2004

Sample size: 44 households

Materials	Collected as refuse (kg)	Arisings kg/hhld/wk	Arisings summary kg/hhld/wk	Assay of Arisings wt %	Assay summary wt %	Potential recyclables kg/hhld/wk	P. recyclables summary kg/hhld/wk	Potential recyclables wt %	P. recyclables summary wt %
Newspapers	64.84	1.47		9.58		1.47		9.58	
Magazines	24.54	0.56		3.63		0.56		3.63	
Recyclable Office Paper	5.62	0.13		0.83		0.13		0.83	
Cardboard Boxes/Containers	33.64	0.76	4.07	4.97	26.48	0.76	3.52	4.97	22.90
Multi-Layer Packaging	3.12	0.07		0.46		-		-	
Other Paper and Card	26.38	0.60		3.90		0.60		3.90	
Non-recyclable Paper	21.08	0.48		3.11		-		-	
Refuse Sack and Carrier Bags	10.66	0.24		1.57		-		-	
Packaging Film	11.18	0.25	0.50	1.65	3.26	-	0.00	-	0.00
Other Plastic Film	0.21	0.00		0.03		-		-	
PET Bottles, Clear	6.81	0.15		1.01		0.15		1.01	
PET Bottles, Coloured	1.95	0.04		0.29		0.04		0.29	
HDPE Bottles, Clear	5.81	0.13		0.86		0.13		0.86	
HDPE Bottles, Coloured	3.51	0.08		0.52		0.08		0.52	
PVC Bottes, Clear & Coloured	0.24	0.01	0.96	0.04	6.24	0.01	0.64	0.04	4.18
PP Bottles, Clear & Coloured	0.76	0.02		0.11		0.02		0.11	
Food Packaging	14.26	0.32		2.11		0.16		1.05	
Non-Food Packaging	4.17	0.09		0.62		0.05		0.31	
Other Dense Plastics	4.74	0.11		0.70		-		-	
Textiles	16.42	0.37	0.37	2.43	2.43	-	0.00	-	0.00
Shoes	2.12	0.05		0.31		-		-	
Disposable Nappies & San. towels	24.44	0.56		3.61		-		-	
Wood	3.21	0.07	1.40	0.47	9.08	-	0.00	-	0.00
Carpet and Underlay	3.63	0.08		0.54		-		-	
Furniture	0	-		-		-		-	
Other Misc. Combustible	28.07	0.64		4.15		-		-	
C & D Waste	2.06	0.05	0.08	0.30	0.55	-	0.00	-	0.00
Other MNC	1.64	0.04		0.24		-		-	
Packaging Glass	39.61	0.90	0.95	5.85	6.18	0.90	0.90	5.85	5.85
Non-Packaging Glass	2.24	0.05		0.33		-		-	
Food and Beverage cans	11.98	0.27	0.41	1.77	2.66	0.27	0.27	1.77	1.77
Other Ferrous Metals	6.03	0.14		0.89		-		-	
Food and Beverage cans	4.34	0.10		0.64		0.10		0.64	
Aluminium Foil	1.38	0.03	0.17	0.20	1.09	-	0.10	-	0.64
Other Non-Ferrous Metal	1.63	0.04		0.24		-		-	
Kitchen-Raw veggies + Peel	77.97	1.77		11.52		1.77		11.52	
Kitchen- Processed Food + meat	95.65	2.17		14.13		-		-	
Liquids	6.5	0.15	5.82	0.96	37.81	-	3.37	-	21.92
Garden Waste	70.39	1.60		10.40		1.60		10.40	
Other Putrescibles	5.38	0.12		0.79		-		-	
Lead/acid batteries	0	-		-		-		-	
Oil	9.73	0.22	0.24	1.44	1.57	-	0.00	-	0.00
Identifiable Clinical waste	0.91	0.02		0.13		-		-	
Other Potentially Hazardous	0	-		-		-		-	
White Goods	0	-		-		-		-	
Large Electronic Goods	8.45	0.19	0.24	1.25	1.54	-	0.00	-	0.00
TVs and Monitors	0	-		-		-		-	
Other WEEE	1.97	0.04		0.29		-		-	
<10mm	7.58	0.17	0.17	1.12	1.12	-	-	-	-
Totals	676.85	15.38	15.38	100.00	100.00	8.81	8.81	57.27	57.27

Table A6.6 Waste analysis data for 'Recycling only' households – Nov 2004

Sample size: 50 households

Materials	Collected as refuse (kg)	Arisings kg/hhld/wk	Arisings summary kg/hhld/wk	Assay of Arisings wt %	Assay summary wt %	Potential recyclables kg/hhld/wk	P. recyclables summary kg/hhld/wk	Potential recyclables wt %	P. recyclables summary wt %
Newspapers	21.77	0.44	3.21	2.88	21.24	0.44	2.56	2.88	16.98
Magazines	18.46	0.37		2.45		0.37		2.45	
Recyclable Office Paper	12.83	0.26		1.70		0.26		1.70	
Cardboard Boxes/Containers	45.94	0.92		6.09		0.92		6.09	
Multi-Layer Packaging	4.84	0.10		0.64		-		-	
Other Paper and Card	29.13	0.58		3.86		0.58		3.86	
Non-recyclable Paper	27.34	0.55		3.62		-		-	
Refuse Sack and Carrier Bags	11.1	0.22	0.55	1.47	3.62	-	0.00	-	0.00
Packaging Film	15.53	0.31		2.06		-		-	
Other Plastic Film	0.67	0.01		0.09		-		-	
PET Bottles, Clear	5.7	0.11	0.91	0.76	6.06	0.11	0.55	0.76	3.63
PET Bottles, Coloured	2.35	0.05		0.31		0.05		0.31	
HDPE Bottles, Clear	5.37	0.11		0.71		0.11		0.71	
HDPE Bottles, Coloured	2.89	0.06		0.38		0.06		0.38	
PVC Bottes, Clear & Coloured	0.34	0.01		0.05		0.01		0.05	
PP Bottles, Clear & Coloured	0.79	0.02		0.10		0.02		0.10	
Food Packaging	15.16	0.30		2.01		0.15		1.00	
Non-Food Packaging	4.74	0.09		0.63		0.05		0.31	
Other Dense Plastics	8.38	0.17		1.11		-		-	
Textiles	9.13	0.18	0.18	1.21	1.21	-	0.00	-	0.00
Shoes	1.75	0.04	1.30	0.23	8.62	-	0.00	-	0.00
Disposable Nappies & San. towels	17.7	0.35		2.35		-		-	
Wood	9.2	0.18		1.22		-		-	
Carpet and Underlay	4.03	0.08		0.53		-		-	
Furniture	0	-		-		-		-	
Other Misc. Combustible	32.4	0.65		4.29		-		-	
C & D Waste	17.54	0.35	0.38	2.32	2.51	-	0.00	-	0.00
Other MNC	1.43	0.03		0.19		-		-	
Packaging Glass	25.13	0.50	0.61	3.33	4.02	0.50	0.50	3.33	3.33
Non-Packaging Glass	5.22	0.10		0.69		-		-	
Food and Beverage cans	10.48	0.21	0.33	1.39	2.19	0.21	0.21	1.39	1.39
Other Ferrous Metals	6.07	0.12		0.80		-		-	
Food and Beverage cans	1.18	0.02	0.16	0.16	1.07	0.02	0.02	0.16	0.16
Aluminium Foil	3.04	0.06		0.40		-		-	
Other Non-Ferrous Metal	3.89	0.08		0.52		-		-	
Kitchen-Raw veggies + Peel	101.35	2.03	7.26	13.43	48.09	2.03	4.07	13.43	26.99
Kitchen- Processed Food + meat	110.9	2.22		14.69		-		-	
Liquids	8.93	0.18		1.18		-		-	
Garden Waste	102.35	2.05		13.56		2.05		13.56	
Other Putrescibles	39.42	0.79		5.22		-		-	
Lead/acid batteries	0	-	0.05	-	0.32	-	0.00	-	0.00
Oil	0	-		-		-		-	
Identifiable Clinical waste	0.16	0.00		0.02		-		-	
Other Potentially Hazardous	2.23	0.04		0.30		-		-	
White Goods	0	-	0.01	-	0.09	-	0.00	-	0.00
Large Electronic Goods	0	-		-		-		-	
TVs and Monitors	0	-		-		-		-	
Other WEEE	0.65	0.01		0.09		-		-	
<10mm	7.23	0.14	0.14	0.96	0.96	-	-	-	-
Totals	754.74	15.09	15.09	100.00	100.00	7.92	7.92	52.47	52.47

Table A6.7 Waste analysis data for ‘Recycling and composting’ households – Nov 2004

Sample size: 48 households

Materials	Collected as refuse (kg)	Arisings kg/hhld/wk	Arisings summary kg/hhld/wk	Assay of Arisings wt %	Assay summary wt %	Potential recyclables kg/hhld/wk	P. recyclables summary kg/hhld/wk	Potential recyclables wt %	P. recyclables summary wt %
Newspapers	5.39	0.11		1.04		0.11		1.04	
Magazines	12.65	0.26		2.45		0.26		2.45	
Recyclable Office Paper	4.71	0.10		0.91		0.10		0.91	
Cardboard Boxes/Containers	31.81	0.66	2.13	6.15	19.74	0.66	1.64	6.15	15.23
Multi-Layer Packaging	4.41	0.09		0.85		-		-	
Other Paper and Card	24.21	0.50		4.68		0.50		4.68	
Non-recyclable Paper	18.94	0.39		3.66		-		-	
Refuse Sack and Carrier Bags	8.39	0.17		1.62		-		-	
Packaging Film	12.24	0.26	0.43	2.37	4.02	-	0.00	-	0.00
Other Plastic Film	0.16	0.00		0.03		-		-	
PET Bottles, Clear	3.59	0.07		0.69		0.07		0.69	
PET Bottles, Coloured	1.26	0.03		0.24		0.03		0.24	
HDPE Bottles, Clear	5.27	0.11		1.02		0.11		1.02	
HDPE Bottles, Coloured	2.83	0.06		0.55		0.06		0.55	
PVC Bottes, Clear & Coloured	0.03	0.00	0.75	0.01	6.96	0.00	0.46	0.01	4.23
PP Bottles, Clear & Coloured	0.59	0.01		0.11		0.01		0.11	
Food Packaging	12.13	0.25		2.35		0.13		1.17	
Non-Food Packaging	4.5	0.09		0.87		0.05		0.44	
Other Dense Plastics	5.783	0.12		1.12		-		-	
Textiles	10.88	0.23	0.23	2.10	2.10	-	0.00	-	0.00
Shoes	2.39	0.05		0.46		-		-	
Disposable Nappies & San. towels	13.57	0.28		2.62		-		-	
Wood	4.62	0.10	1.06	0.89	9.85	-	0.00	-	0.00
Carpet and Underlay	0	-		-		-		-	
Furniture	0	-		-		-		-	
Other Misc. Combustible	30.35	0.63		5.87		-		-	
C & D Waste	3.02	0.06	0.24	0.58	2.25	-	0.00	-	0.00
Other MNC	8.61	0.18		1.66		-		-	
Packaging Glass	9.65	0.20	0.29	1.87	2.69	0.20	0.20	1.87	1.87
Non-Packaging Glass	4.26	0.09		0.82		-		-	
Food and Beverage cans	2.77	0.06	0.18	0.54	1.71	0.06	0.06	0.54	0.54
Other Ferrous Metals	6.07	0.13		1.17		-		-	
Food and Beverage cans	0.26	0.01		0.05		0.01		0.05	
Aluminium Foil	1.51	0.03	0.06	0.29	0.55	-	0.01	-	0.05
Other Non-Ferrous Metal	1.08	0.02		0.21		-		-	
Kitchen-Raw veggies + Peel	64.37	1.34		12.45		1.34		12.45	
Kitchen- Processed Food + meat	57.93	1.21		11.20		-		-	
Liquids	0.68	0.01	5.00	0.13	46.45	-	3.65	-	33.85
Garden Waste	110.69	2.31		21.40		2.31		21.40	
Other Putrescibles	6.55	0.14		1.27		-		-	
Lead/acid batteries	0	-		-		-		-	
Oil	0	-	0.06	-	0.54	-	0.00	-	0.00
Identifiable Clinical waste	0.92	0.02		0.18		-		-	
Other Potentially Hazardous	1.88	0.04		0.36		-		-	
White Goods	0	-		-		-		-	
Large Electronic Goods	2.37	0.05	0.17	0.46	1.59	-	0.00	-	0.00
TVs and Monitors	0	-		-		-		-	
Other WEEE	5.83	0.12		1.13		-		-	
<10mm	8.05	0.17	0.17	1.56	1.56	-	-	-	-
Totals	517.20	10.78	10.78	100.00	100.00	6.01	6.01	55.76	55.76

APPENDIX VII – Literature Review

A7.1 Household waste management

There is increased awareness of the potential environmental impacts associated with landfill disposal of municipal solid waste (MSW) and the problem of decreasing availability of landfill space (Alter 1991; Finstein 1992; Hartlieb *et al.*, 2003). In particular, reducing biodegradable waste disposal by landfilling is a principal objective of European legislation on waste management (EC, 1999) to limit leachate and greenhouse gas emissions at landfill sites. The UK Government set out its policy framework for sustainable waste management, which targets the reduction of waste, to lessen environmental impacts of waste disposal, diminish the use of resources, and produce savings in the other inputs that might have gone into processing the materials, such as energy and labour (DETR, 2000). The Government and the National Assembly are committed to tackle the amount of waste produced by breaking the link between economic growth and waste production and by putting waste to good use through substantial increases in re-use, recycling, composting and recovery of energy.

The achievement of the governmental targets for sustainable waste management necessitates the cooperation between local authorities, waste industry and consumers. In the UK, a single or a two-tier system exists within the local government for the management of municipal waste. In Scotland, Northern Ireland and parts of England and Wales, the Unitary or Metropolitan Authority is responsible for both the collection and disposal of MSW, whereas the remainder of the UK has a two-tier system, in which District and County councils divide responsibilities of MSW collection and disposal. District Councils (the London Boroughs in Greater London) are the waste collection authorities (WCAs) and have the duty to provide receptacles for household waste, collection of household waste, and sometimes any commercial waste, and delivery of waste to a place of disposal. On the other hand, County Councils are the waste disposal authorities and are in charge for arranging for the safe disposal of the waste collected by the WCAs and pay a fee per t of waste delivered to the WDA.

A7.2 Household waste arisings

Municipal solid waste is defined as ‘all waste collected by on behalf of the local authority, and includes all household waste, street litter, waste delivered to council recycling points, municipal parks and garden wastes, council office waste, civic amenity waste, and some commercial waste from shops and smaller trading estates where local authority waste collection agreements are in place’ (DETR, 1999a).

The Department of Environment, Food and Rural Affairs (DEFRA) has carried out ten municipal waste management surveys published by the National Statistics, which provide a comprehensive picture of municipal waste management in England. Questionnaires were sent to all WCAs, WDAs and UAs in England (394 in total), requesting information on the amounts of municipal waste collected and disposed of, the levels of recycling and recovery of household and municipal waste, methods of waste containment, levels of service provision and details of waste collection and disposal contracts. All the waste figures that are presented in the following paragraphs refer to the most recent waste management survey which was undertaken during the financial year 2003/04.

It has been estimated that 29.1 million t of MSW were generated during 2003/04 in England, compared to 29.4 million t in 2002/03 (DEFRA, 2005; DEFRA, 2004a). This represents a 1% reduction in MSW arisings, which is the first reduction in municipal waste generation reported during the recent years. The majority of MSW arisings comes from households: 25.4 million t of household waste were collected in 2003/04, which accounts for 87% of total MSW. Household waste includes waste from household collection rounds, waste from services such as street sweeping, bulky waste collection, hazardous household waste collection, litter collections, household clinical waste collection and separate garden waste collection, waste from civic amenity sites and wastes separately collected for recycling or composting through bring/drop off schemes, kerbside schemes and at civic amenity sites (DEFRA, 2003b).

Total household waste has increased by 13% between 1996/97 and 2003/04 from 22.5 million to 25.4 million tonnes, an average increase of 1.7% per year. The rate of annual increase has been slowing over time, and between year 2000/01 and 2003/04 did not exceed 2% (DEFRA, 2005). The average amount of waste produced weekly by a household was 23.1 kg, which is 0.7 kg less than the average weekly amount in 2002/03 (DEFRA, 2005; DEFRA, 2004a). Figure A7.1 depicts the proportion of total MSW that is attributed to household and non-household sources. In 2003/04, 55% of municipal waste was from regular household collections (recycling collections were excluded) and the next largest source was waste collected for recycling from household sources, which accounted for 16% of total MSW. Only 9% of the total arisings was waste from non-household sources.

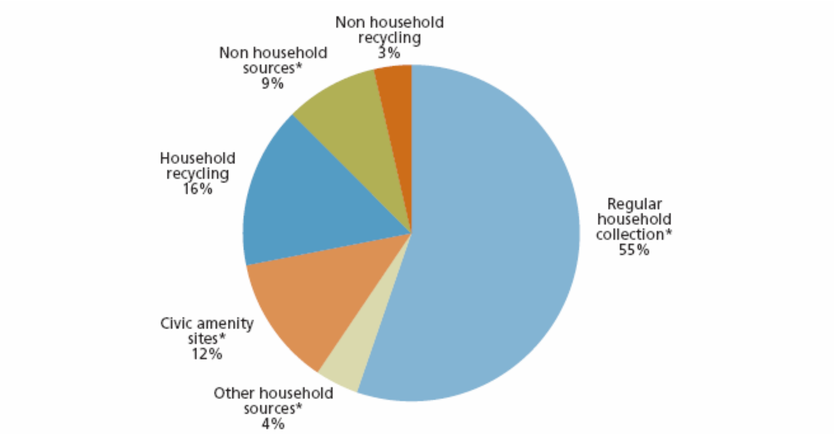


Figure A7.1 Municipal waste arisings (excl recycling), England 2003/04 (DEFRA, 2005)

In 2003/04 the average amount per household from the regular collection was 14.6 kg per week, a fall from 15.1 kg per week in 2002/03. In Table A7.1, the types of waste containment for the regular collection round supplied by the local authority have been split into four categories. Methods included within the 'other' category include multiple occupancy systems and standard dustbins. The type of waste containment supplied has changed little from 2002/03, with a small increase in the authorities supplying wheeled bins. Figure A7.2 depicts the mean weight of household waste collected and recycled by households in each of the waste containment categories.

Although areas that use wheeled bins are highly served by kerbside collection schemes (80%), they generally generate more total waste (23.8 kg/hh/wk) and recycle less (3.9 kg/hh/wk) than those areas that supply only plastic sacks or no waste containment. Parfitt (2002) suggests the higher level of waste generated can be partly explained by the tendency of wheeled bins to be used in areas with a higher proportion of detached or semi-detached households which are occupied by a larger number of people. This fact implies that the average amount of waste disposed weekly by a household with a wheeled bin might be larger than the amount of waste disposed per capita.

About 8.1 million t (28%) of municipal waste had some sort of value (recycling, composting, energy recovery, RDF manufacture) recovered from it in 2003/04 up from 7.3 million t, or 24.7% of total municipal waste in 2002/03. The proportion of municipal waste being recycled or composted has increased from 15.6% in 2002/03 to 19% in 2003/04, while the proportion of waste incinerated with energy recovery has remained roughly constant at 9%.

Table A7.1 Method of refuse collection round waste containment and recycling rate: England, 2003/04 (DEFRA, 2005)

	Percentage of authorities	Percentage of households served kerbside collection	Total household waste collected kg/hh/wk	Quantity collected for recycling kg/hh/wk	Recycling rate (including composting)
Wheeled bin	56%	80%	23.8	3.9	16.5%
Plastic sack	23%	73%	22.8	4.4	19.3%
No method provided	18%	68%	21.7	4.5	20.8%
Other	3%	81%	20.6	2.6	12.9%
Total	**100%**	**79%**	**23.2**	**4.1**	**17.7%**

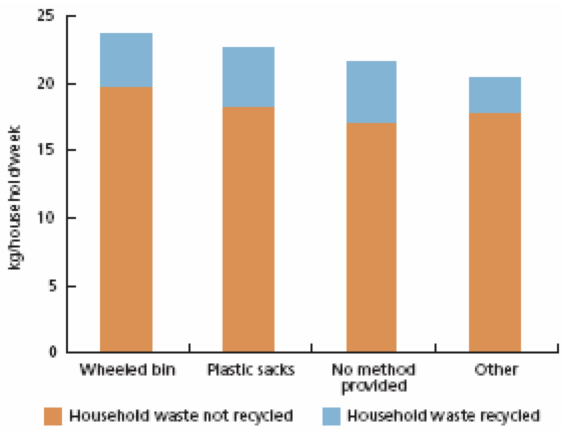


Figure A7.2 Mean weight of household waste arisings by method of refuse collection round waste containment in 2003/04 (DEFRA, 2005)

In March 2006, DEFRA released the provisional municipal waste management statistics for the financial year 2004/05, which for the first time were collected through WasteDataFlow, the government based quarterly system for local authority waste data reporting (DEFRA, 2006; WasteDataFlow, 2005). Briefly, the total amount of municipal waste has increased to an estimated 29.7 million t in England, an increase of 2.1%, and the proportion of MSW being recycled or composted increased from 19% to 23.5%. Household waste has increased slightly by 1.2%, from 25.4 million t in 2003/04 to 25.7 million t in 2004/05, and accounted for 86% of municipal waste. About 513 kg of household waste was collected per person per year, compared to 510 kg in 2003/04.

The Welsh Assembly Government's Waste Strategy Unit is currently responsible for collecting and reporting municipal waste data through WasteDataFlow. The total amount of MSW collected in Wales in 2004/05 was 1.93 million tonnes, a 6% increase compared to the 1.82 million t collected in 2003/04 (National Assembly for Wales, 2006). The three largest components of municipal waste arisings in 2004/05 were regular household collections (52%), household recycling and composting (15%) and non-household sources (11%) (Figure A7.3).

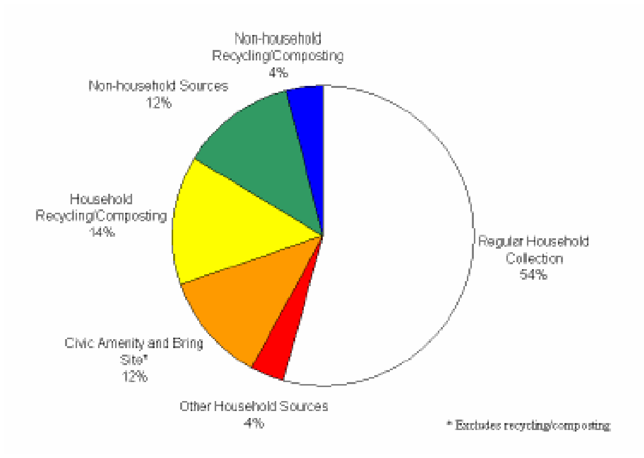


Figure A7.3 Municipal waste arisings in Wales in 2004/05 (The National Assembly for Wales, 2006)

Waste from household sources was 1.58 million t which accounted for 82% of MSW in 2004/05. The amount of household waste produced by a household weekly was 24.3 kg and the amount of household waste produced per capita per week was 10.3 kg (Table A7.2). A total of 286,455 t (18.1%) of household waste was collected for recycling and composting in 2004/05, rising from 251,651 t (16.5%) in 2003/04. Table A7.3 presents the total arisings of household and non-household waste in Wales in 2004/05. Almost half of the households (49.2%) were provided with the plastic sack containment method for regular household collection, followed by the wheeled bin (37.5%) (Table A7.4).

The Environment and Heritage Service, an agency within the Department of the Environment (NI), published a summary report for the municipal and household waste arisings in Northern Ireland by data provided by all 26 district councils in Northern Ireland (Environment and Heritage Service, 2005). According to this report, the total amount of municipal waste arisings in Northern Ireland in 2004/05 were 1,050,716 t, an increase of 2.3% from 1,026,679 t in 2003. The proportion of municipal waste recycled and composted has increased by 6%, from 12.2% in 2003 to 18.2% in 2004/05.

Table A7.2 Amount of household waste arising per household and per capita per week in Wales in 2003/04 and 2004/05 (The National Assembly for Wales, 2006)

Household waste category[1]	2003/04		2004/05	
	kg/hh[2]/wk	kg/ca[2]/wk	kg/hh[2]/wk	kg/ca[3]/wk
Regular collection	15.5	6.4	15.4	6.5
Other household	1.0	0.4	1.2	0.5
Civic amenity site	3.4	1.4	3.3	1.4
Household recycling	2.5	1.0	3.0	1.3
Household composting	1.5	0.6	1.3	0.6
Total household	**24.0**	**9.9**	**24.3**	**10.3**

Note: 1. Table does not include abandoned vehicle arisings
2. Household figures from StatsWales
3. Mid year estimates (MYE)

The total amount of household waste arisings in Northern Ireland in 2004/05 was 919,169 t, compared with 897,655 t in 2003, which represents an increase of 2.4%. Household waste accounted for 87.4% of municipal waste in 2004/05 and the average amount of waste produced per household per week was 26.2 kg. About 173,723 t (18.9%) of household waste was collected for recycling and composting, compared to 112,207 t (12.5%) in 2003.

Scotland supports the key concepts of WasteDataFlow but with its own data collection initiatives still bedding in it plans to monitor developments in the other three countries with a view to joining the system in 2005/06. The data presented in this report (Table A7.5) are based on the returns provided for the Local Authority Waste Arisings Survey (LAWAS) 2003/2004 undertaken by the Scottish Environment Protection Agency (SEPA). All 32 Scottish local authorities responded to SEPA's 2003/2004 LAWAS (SEPA, 2005). In 2003/2004, a total of 3.32 million t of controlled wastes was collected by, or on behalf of, local authorities in Scotland, of which 2.83 million t was municipal waste and 2.35 million t was household waste (Table A7.5). The combined recycling and composting rate for Scotland was 16.39% of household waste for 2003/2004. The publication of SEPA's waste data report for 2004/05 (Waste Data Digest 6) was delayed and is now expected to be published in autumn 2006. However, the waste arisings for 2004/05 (Table A7.6) were obtained by personal communication with Dr Peter Olsen at SEPA's Stirling office (SEPA, 2006).

The household waste data of the four countries were added together to obtain the total amount of municipal and household waste produced in the UK during the financial year 2004/05. The total municipal waste generated in the UK in 2004/05 was 36.12 million t, of which 30.99 million t (86%) was household waste (Table A7.7). About 22.2% of municipal waste was recycled and composted, which is equal to 8.2 million t. The amount of household waste that was collected for recycling or composting was 6.75 million t, raising the recycling rate for household waste in the UK to 21.8%. The majority of household waste was collected through the regular household collection (18.9 million t).

A7.3 Household waste compositional analysis

Compositional data are important in identifying the types of materials that are present in a waste stream and the quantities that may be potentially diverted through recycling and composting. Waste compositional analyses are most commonly conducted on the residual waste elements, such as household collected bag or bin waste, but it is also possible to conduct analyses on material arising from other household waste streams, such as waste collected through kerbside recycling collection schemes or Civic Amenity site waste (DEFRA, 2004b).

A7.3.1 Waste compositional analysis in the UK

According to Parfitt (2002) there is confusion over the meaning and validity of statistics resulted from household waste compositional analyses in the UK. This is partly attributed to the inactive for a decade National Household Waste Analysis Programme (NHWAP), to the lack of recent estimates and to the reference of MSW as the representative waste found in the refuse bin. Moreover, the lack of general guidelines for the methodological requirements for waste analysis and the initiative of local authorities to carry out their own compositional analyses add further confusion. More severe are the implications at national level where the lack of credible national estimates affect the development of waste policies.

Table A7.3 Municipal waste arisings in Wales in 2003/04 and 2004/05 (The National Assembly for Wales, 2006)

	2003/04		2004/05	
Municipal waste category[4]	**Quantity (t)**	**% of total MSW**	**Quantity (t)**	**% of total MSW**
Household waste				
Regular household collection	985,989	54.2	1,005,395	52.1
Other household sources	66,022	3.6	65,477	3.4
Bulky collections	…	…	9,830	0.5
Civic amenity site[1]	218,492	12.0	217,482	11.3
Household recycling[2]	158,336	8.7	198,578 r	10.3
Household composting[2]	93,314	5.1	87,877 r	4.6
Total household waste	1,522,154	83.6	1,584,638	82.2
Non-household waste				
Non-household sources	227,102	12.5	212,597	11.0
Non-household recycling	53,204	2.9	81,506 r	4.2
Non-household composting	17,705	1.0	49,586 r	2.6
Total non-household	298,012	16.4	343,689	17.8
Municipal waste				
Total recycling	211,541	11.6	280,084 r	14.5
Total composting	111,020	6.1	137,462 r	7.1
Total municipal waste	1,820,166	100.0	1,928,327	100.0

Note:
1. 'Civic amenity site' excludes materials recycled/composted.
2. Household 'recycling/composting' includes materials collected by kerbside schemes, from bring and civic amenity sites and by private and voluntary organisations. Rubble, beach cleaning, abandoned vehicles and incinerator residues are excluded.
3. Non-household 'recycling/composting' includes waste collected through local authority contracts for centralised composting and from other facilities for glass, scrap metal, paper and card etc.
4. Table does not include abandoned vehicle arisings.

Table A7.4 Proportion of households provided with different methods of waste containment in Wales in 2004/5 (The National Assembly for Wales, 2006)

Containment method	2003/04	2004/05
Wheeled bin	38.3	37.5
Plastic sack	50.4	49.2
Refuse bin	2.6	2.5
Multi-occupancy systems	0.9	1.2
No method provided	7.4	7.2
Other method provided	0.3	2.4
Total	**100.0**	**100.0**

Table A7.5 Total controlled waste collected by or on behalf Scottish Local Authorities 2003/04 (SEPA, 2005)

Waste type	Quantity (t)	% of total waste
Waste collected for disposal		
Household*	2,015,578	60.76
Civic amenity sites¡	359,875	10.85
Commercial sources	452,428	13.64
Industrial sources	29,987	0.90
Other non-household sources¿	62,473	1.88
Total	**2,920,341**	**88.04**
Waste collected for recycling and composting		
Household	330,396	9.96
Non-household§	66,678	2.00
Total	**396,678**	**11.96**
Total arisings¶	**3,317,019**	**100.00**
Total MSW	**2,834,604**	**85.46**
Total household	**2,345,974**	**70.73**

Note:

* For many local authorities, the mainstream household waste collection service is a mixed collection and includes household, commercial and industrial wastes. For the purpose of the LAWAS, local authorities provided the data for household, commercial and industrial waste from this collection round separately.

¡ Civic amenity sites waste includes both household and commercial waste.

¿ Other non-household waste includes: local authority parks and garden waste; beach cleaning waste; clearance of fly tipped waste; abandoned vehicles; and waste not otherwise specified.

§ Includes incinerator residues.

¶ Waste arisings do not include home composting tonnages.

Table A7.6 Total controlled waste collected by or on behalf Scottish Local Authorities 2004/05 (SEPA, 2006)

Waste type	Quantity (t)	% of total waste
Waste collected for disposal		
Household*	2,275,611	64.90
Commercial sources	487,530	13.90
Industrial sources	72,146	2.06
Other non-household sources¿	24,166	0.69
Total	**2,859,453**	**82.47**
Waste collected for recycling and composting		
Household	521,812	14.88
Commercial§	98,083	2.80
Industrial§	26,940	0.77
Total	**646,834**	**18.45**
Total arisings¶	**3,506,287**	**100.00**

Note:

* For many local authorities, the mainstream household waste collection service is a mixed collection and includes household, commercial and industrial wastes. For the purpose of the LAWAS, local authorities provided the data for household, commercial and industrial waste from this collection round separately.

¿ Other non-household waste includes: local authority parks and garden waste; beach cleaning waste; clearance of fly tipped waste; and waste not otherwise specified.

§ Includes incinerator residues.

¶ Waste arisings do not include home composting tonnages and road maintenance waste.

Table A7.7 Municipal and household waste arisings in the UK for 2004/05 (units: thousands of t)

Household waste from:	ENGLAND[1]	WALES[2]	SCOTLAND[3]	N. IRELAND[4]	UK
Regular household collection	15,507	965	1864	560	18,896
Other household sources	1,201	85	144	21	1,451
Civic amenity sites	3,211	249	268	164	3,892
Household recycling (inc. composting)	5,769	286	522	174	6,751
Total household waste	**25,688**	**1585**	**2798**	**919**	**30,990**
Non household sources (excl. recycling)	2,832	213	512	115	3,672
Non household recycling (inc. composting)	1,213	131	98	17	1,459
Total municipal waste	**29,734**	**1928**	**3408**	**1051**	**36,121**

Note:
1. England: from DEFRA municipal waste management survey
2. Wales: Welsh Assembly Government
3. Scotland: from Scottish Environment Protection Agency
4. Northern Ireland: Environment & Heritage Services

To moderate the consequences of the absence of a standard methodology for waste composition analysis, the DEFRA designed a guide to assist local authorities to develop a better understanding of waste composition analysis and to improve waste management practices (DEFRA, 2004b). Although the guide is not a comprehensive operational manual for conducting a waste analysis and as such it does not recommend any methodology, it provides guidance on what information can be obtained by a waste analysis, how to interpret and make use of waste analysis data, how the results of an analysis link to other waste data, and finally, how to specify a waste analysis that will deliver the good quality data required.

The last national study in England was the study conducted by the Environment Agency in 1997, (Parfitt *et al.*, 1997). Prior to this was the National Household Waste Analysis Programme (NHWAP) undertaken by the former Warren Spring Laboratory between 1991 and 1994 for the Department of the Environment (DoE).The results of NHWAP had been widely disseminated as they were the only national statistics for household waste composition in the UK and have been used by policy-makers at national and local levels (Parfitt and Flowerdew, 1997). The sampling strategy of NHWAP was based on the use of a commercially available system of classified residential area profiles, called ACORN (A Classification of Residential Neighbourhoods), which is still in use in its updated version, using the 2001 census data, by several compositional analyses nowadays. The Environment Agency has commenced the third phase of the 'Household Waste Analysis Programme' in December 2002 and the project is planned to report in 2006. The main objective of the new phase of the programme is to examine the feasibility of incorporating compositional data on specific waste streams in the national waste database to promote the exchange of waste material for reuse and recycling on a national scale (Environment Agency, 2004).

The Welsh Assembly has undertaken a comprehensive national waste survey between November 2000 and October 2003 which led to the development of a protocol for analysis of each waste stream. The protocol provided further data on the composition of waste streams such as litter, bulky household waste and street sweepings and initial data on the composition of commercial and industrial waste, compiled household characteristics through a questionnaire survey to correlate with waste generation, and finally, identified seasonal trends in the composition of MSW waste streams (AEA Technology *et al.*, 2003). Further research has being carried out by the SWAT (Solid Waste Analysis Tool) project, where the participating 14 European partners aim to implement a standardised methodology for solid waste analyses and improve the accuracy and comparability of municipal waste data across Europe (SWAT, 2004).

Moreover, the Scottish Environment Agency (SEPA) has recognised that using a standard methodology would facilitate monitoring of progress towards Landfill Directive targets, provide information for the Landfill Allowance Scheme and inform requirements for medium to long term management of waste. Those reasons lead SEPA to publish a consultation paper in response to a number of requests from Scottish Local Authorities for a standardised methodology for conducting analyses of municipal solid waste upon local municipal waste streams to identify and quantify the Biodegradable Municipal Waste (BMW) content and quantify the recyclable content (SEPA, 2004).

A7.3.2 Factors influencing composition of household waste

Household waste composition varies not only across countries, but also by region due to a series of factors such as:

- Socio-economic and demographic status;
- Consumption habits;
- Changes in waste management services;
- Season of waste collection;
- Whether or not households have gardens;
- Presence of tourists.

Another factor with a significant contribution to the diversity of the reported waste compositional statistics is the methodology used in the collection of waste fractions. Where waste fractions are co-mingled, then the wet weights are reported because of the transfer of moisture from one fraction to another which increases the apparent quantity of paper and cardboard and reduces the biodegradable fraction. On the other hand, if the same waste was collected in separate fractions, the possibilities for moisture transfer would be reduced. Therefore, the different methodologies produce data that are only comparable where the same methodology is used.

Furthermore, the proportion of the totality of materials potentially arising as waste which the compositional analyses address will vary across the counties due to different levels of promotion and implementation of home composting and kerbside collection practices in the area. For example, it is anticipated for a waste sample taken from a refuse container in a county where home composting is encouraged to contain less biodegradable material.

A7.3.3 Waste fractions in household waste

A large number of local authorities and organisations undertake their own compositional analyses of household waste for different purposes, rendering comparison between waste compositional data difficult as surveys rarely share common waste categories or sampling methodologies. An attempt to combine household waste compositional data and obtain the best estimates for England in 2000/01 was carried out by Parfitt (2002) (Table A7.8). The results were used into the Strategy Unit 2000 municipal waste modelling exercise.

Average production of the most significant fractions in the household waste stream is presented in the Strategy Unit Report and the Waste Strategy (Strategy Unit, 2002; DETR, 2000). The waste data in the former report refer to household waste arisings in England only, whereas the latter report contains data for both England and Wales. Table A7.9 shows the average percentage by weight of the household waste fractions encompassed in these two reports, highlighting the regional variability of waste compositional statistics due to the factors mentioned previously.

A7.4 Waste disposal and treatment practices

Sustainability and the Best Practicable Environmental Option (BPEO) are the guiding principles which govern the waste management strategy. The treatment and disposal of waste is one of the central themes of sustainable development and should comprise the option that provides the most benefit or least damage to the environment as a whole at an acceptable cost in the long and short term. The European Union (EU) has developed a strategy about the treatment of waste via a series of Directives and Programs, whose key objectives are the minimisation of the amount of waste that is produced and any risk of pollution (Williams, 2002). The EU strategy has been developed in the UK into the concept of a ‘hierarchy of waste management’ (Figure A7.4). The higher levels of the hierarchy reflect more sustainable waste and resource management (Strategy Unit, 2002).

The strategy and the overall policy aim of the UK Government requires that the waste management practices move up the hierarchy such that the waste is not merely disposed of, but should, where possible, be recovered, re-used or minimized. However, this may not be achievable or desirable in all cases, since sometimes waste is best landfilled or incinerated due to the fact that the economic and environmental cost to sort and decontaminate the waste to produce a usable product overweighs the benefits. In selecting a waste treatment and disposal option for household waste, the considerations which must be taken into account include: the capital investment costs of the facility, operating costs, decommissioning and aftercare, throughput of waste and the environmental impact (Williams, 2002).

A7.4.1 Landfill disposal of municipal and household waste

One of the major issues associated with waste management in the UK is the reliance upon landfill disposal of MSW. Landfill is the dominant waste management route in the UK (DEFRA, 2004a) because the geological and hydro-geological conditions have favoured the development of landfill sites at low cost. The predominance of landfill in current UK management practices reflects the fact that even when incorporating the highest engineering standards it is still the most adaptable and least expensive waste management option in most areas (Neil, 1997).

Despite short term economic advantages, disposal of municipal waste in landfills does not comprise a sustainable waste management option. Existing facilities are rapidly coming to the end of their life as the availability of landfill void to accept more waste is diminishing. Moreover, even though the area of land currently occupied by landfill sites is less than 0.2% (28,000ha) of the land area of England and Wales, space approved for landfill sites is set to run out in the next five to ten years (Environment Agency, 2004).

Landfill is no longer regarded as an environmentally sustainable option (RCEP, 1993) due to the environmental impacts arising from leachate and landfill gas (Figure A7.5). Landfill gas is the product of anaerobic degradation of biodegradable waste and methanogenesis and is generated by household and commercial wastes containing significant proportions of biodegradable material. Throughout the lifetime of a landfill site the production of landfill gas from MSW with a typical biodegradable composition is estimated to be in the range between 200 and 500 m^3/t (Williams, 2002; Environment Agency, 2004).

Although landfill gas comprises a wide range of gases, the main components are CH_4 (50-60%) and CO_2 (35-40%) (ETSU,1998). Methane can reach explosive concentrations and represent a significant hazard. Thus, all landfill sites are required to be monitored for landfill gas, and the gas from operational sites must be controlled via proper venting (Williams, 2002). In addition, CH_4 is considered to be a potent ‘greenhouse gas’ with an effect on global warming which is 30 times more than CO_2 (Porteous, 1992).

Table A7.8 Household waste fractions in England 2000/01 (Parfitt, 2002)

	'Bin waste' 'dustbin residuals+kerbside recycling&non CA bring recycling			**Civic amenity site waste** Total CA residuals+recycling Excluded: building rubble		
Category	**(x1000) t**	**kg/hh/yr**	**%wt**	**(x1000) t**	**kg/hh/yr**	**%wt**
Newspapers and magazines	1,501	71	8.1	71	3	1.3
Other recyclable paper	1,073	51	5.8	52	2	0.9
Liquid cartons	77	4	0.4	1	0	0.0
Board packaging	228	11	1.2	90	4	1.6
Card and paper packaging	646	31	3.5	2	0	0.0
Other card	29	1	0.2	5	0	0.1
Non-recyclable paper	638	30	3.5	14	1	0.3
Plastic bottles	388	18	2.1	7	0	0.1
Other dense plastic packaging	395	19	2.1	10	0	0.2
Other dense plastic	114	5	0.6	33	2	0.6
Plastic film	733	35	4.0	18	1	0.3
Textiles	589	28	3.2	111	5	2.0
Glass bottles and jars	1,463	69	7.9	69	3	1.2
Other glass	95	4	0.5	13	1	0.2
Wood	507	24	2.7	488	23	8.8
Furniture	49	2	0.3	255	12	4.6
Disposable nappies	444	21	2.4	0	0	0.0
Other miscellaneous combustibles	111	5	0.6	127	6	2.3
Miscellaneous non combustibles	382	18	2.1	827	39	15.0
Metal cans & foil	622	29	3.4	1	0	0.0
Other non-ferrous metals	0	0	0.0	5	0	0.1
Scrap metal/white goods	544	26	2.9	535	25	9.7
Batteries	0	0	0.0	12	1	0.2
Engine oil	0	0	0.0	7	0	0.1
Garden waste	2,824	134	15.3	2,078	98	37.6
Soil & other organic waste	211	10	1.1	624	30	11.3
Kitchen waste	2,234	106	12.1	17	1	0.3
Non-home compostable kitchen waste	1,865	88	10.1	0	0	0.0
Fines	682	32	3.7	50	2	0.9
Total	**18,441**	**872**	**100.0**	**5,521**	**261**	**100.0**

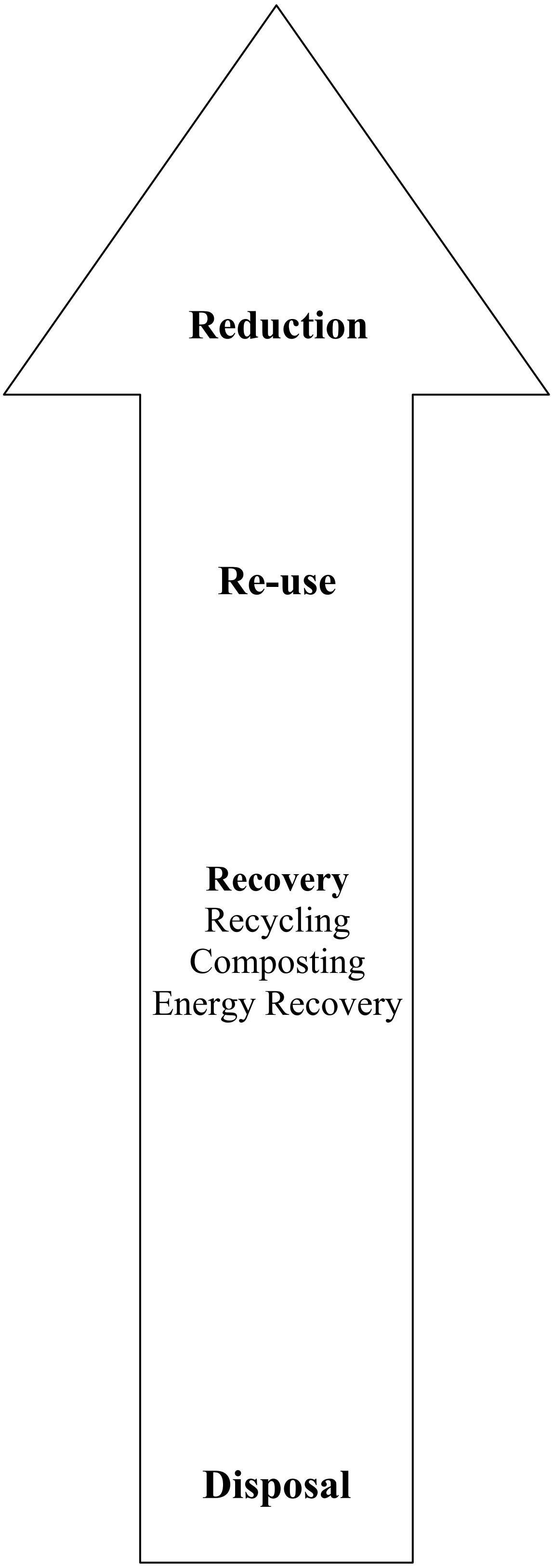
Table A7.9 Household waste fractions (percentage by weight)

Household Waste Fraction	Waste Strategy 2000	Strategy Unit 2002
Paper and card	32	19
Textiles	2	3
Plastic	11	7
Other combustibles	8	8
Glass	9	7
Other non-combustibles	2	4
Metals	8	7
Putrescible waste	21	42
Fines	7	3
Total	**100**	**100**

Leachate represents the water which passes through the waste and water generated within the landfill site, resulting in a liquid containing suspended solids, soluble components of waste and products from the degradation of the waste by various microorganisms. The composition of the leachate depends on the heterogeneity and composition of the waste and whether there is any industrial/hazardous waste co-disposal, the stage of biodegradation reached by the waste, moisture content and operational procedures. The average production of leachate throughout the 30-year design life of a landfill is 276 l/t of landfilled MSW (HMSO, 1995). Prior to its release to a sewer, water course, land or tidal water, leachate must be treated to remove any contaminating components and bring it to a standard whereby its release is permitted (HMSO, 1995).

In the attempt to reduce the amount of waste sent to landfill sites, Landfill Tax on waste disposal through landfill came into force on 1 October 1996. The objectives of introducing Landfill Tax are to ensure that the landfilling of waste is properly priced compared with other waste management options, and to promote a more sustainable approach to waste management. The rate of Landfill Tax for putrescible waste was set at £12 t^{-1} in April 2001 and will rise by a further £1 t^{-1} per annum until a review in 2004. It is applied currently at a rate of £15 t^{-1} for putrescible waste (Environment Agency, 2004).

There has been in decrease in the proportion of municipal waste disposed of to landfills in England, from 75% (22.1 million t) in 2002/03 to 72% in 2003/04 (20.9 million t) (DEFRA, 2005). Some form of value was recovered from the remaining 28% (8.1 million t) of MSW, either through recycling and composting, or through energy recovery. The recently released waste statistics for 2004/05 (DEFRA, 2006) estimate that the actual tonnage of MSW being disposed of to landfills has decreased to 19.9 million t, which means that the proportion of municipal waste being landfilled has fallen to 67%.



Reduction: Reduction of waste at source should be achieved by developing clean technologies and processes that require less material in the end products and produce less waste during manufacture.

Re-use: The collection and re-use of materials like the doorstep milk delivery in the UK involves collection, cleaning and re-use of glass bottles. Though, re-use may not be desirable in all cases since the environmental and economic cost of re-use in terms of energy use, cleaning, recovery, transportation etc may outweigh the benefits.

Recovery: There are a number of different types of waste recovery and these include the following options:

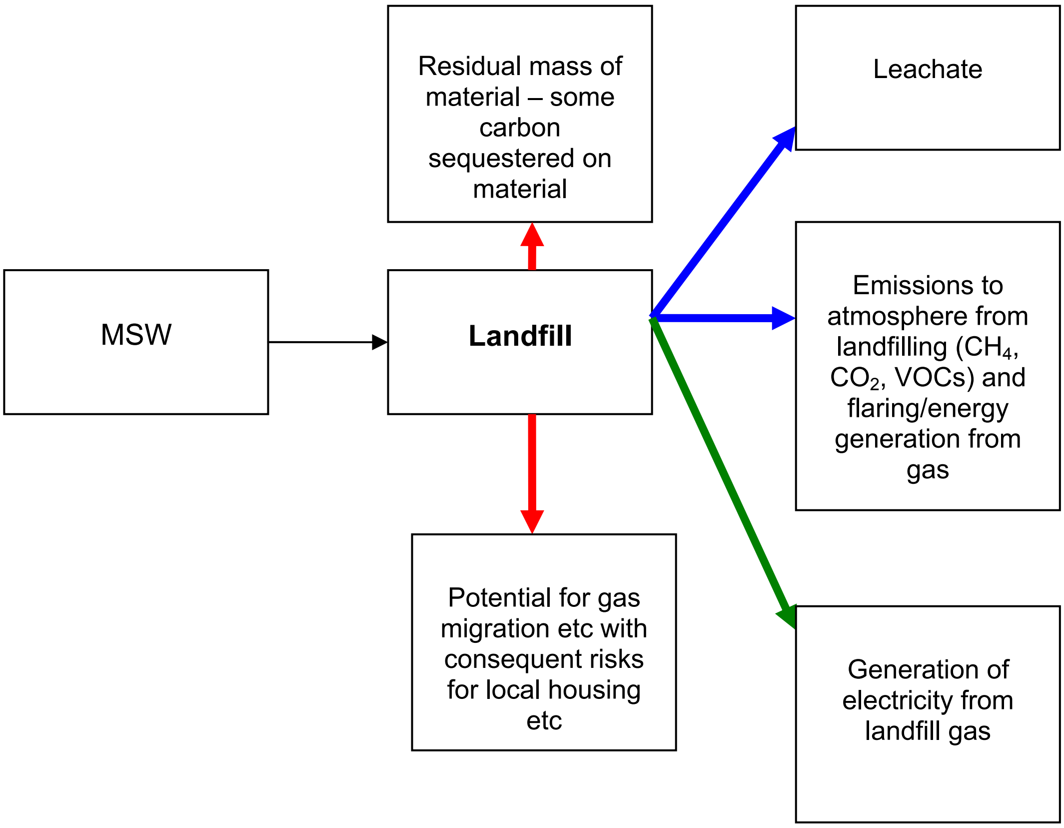
Recycling-The recovery of materials from waste and processing them to produce a marketable product. The potential to recycle material from waste is high, but it may not be appropriate in all cases, such as where the abundance of the raw material, energy consumption during collection and re-processing, or the emission of pollutants has a greater impact on the environment. Materials' recycling also implies that there is a market for recycled materials.

Composting-Decomposition of the organic fraction of waste to produce stable product such as soil conditioners and growing media for plants.

Energy Recovery-Producing energy by incinerating waste or combustion of landfill gas. In incineration of waste, energy is recovered via a boiler to provide hot water for district heating of buildings, or high temperature steam for electricity generation. The incinerator installation represents a high initial capital cost and sophisticated emission control measures are required to clean up the flue gases. The anaerobic digestion of the organic fractions of waste in a landfill site produces a gas consisting mainly of methane which can be collected in a controlled, engineered way and burnt. The derived energy can be used for either district heating or electricity generation.

Disposal: The disposal of waste using processes or methods that do not endanger human health and which cannot harm the environment, such as by incineration or uncontrolled landfill without energy recovery.

Figure A7.4 The hierarchy of waste management (Williams, 2002)



Note: Red arrows represent residual materials
Blue arrows represent 'negative output' (environmental costs)
Green arrows represent 'positive output' (environmental benefits)

Figure A7.5 Schematic representation of landfill inputs and outputs (Eunomia, 2002)

In Wales, the proportion of municipal waste consigned to landfill decreased, from 82% in 2003/04 to 78% in 2004/05. However, due to the 6% rise in the total amount of MSW generated in 2004/05 compared to 2003/04, the total tonnage of municipal waste disposed to landfill increased by 1%, from 1.50 million t in 2003/04 to 1.51 million t in 2004/05 (National Assembly for Wales, 2006). The remaining 22% (419,000 t) of MSW was either recycled and composted, or incinerated with or without energy recovery. Only 709 t of MSW were incinerated without energy recovery, which means that approximately 418,300 t of municipal waste in 2004/05 were recovered.

The same trend in the disposal of municipal waste to landfill in 2004/05 was observed in Northern Ireland. The proportion of MSW being disposed to landfill has fallen by 9.3% since 2002 (Environment and Heritage Service, 2005). In 2004/05, 81.8% of municipal waste was sent to landfill, equating to approximately 859,500 t, while 18.2% (191,000 t) of total MSW was recycled and composted.

In Scotland, as with the rest of the UK countries, there was a decrease in the proportion of MSW consigned to landfill, from 85.4% in 2003/04 to 80.3% in 2004/05 (SEPA, 2005; SEPA, 2006). However, there was only a small decrease in the total tonnage of MSW landfilled because of an increase in the total amount of MSW generated in Scotland in 2004/05 in comparison to the previous year. The total amount of municipal waste landfilled in 2004/05 was 2.74 million t, a drop of 0.6 t from 2003/04. In 2004/05, 19.7% (671,266 t) of total MSW was recovered through recycling, composting, incineration with energy recovery or other method, while the corresponding proportion in 2003/04 was 14.4% (473,332 t).

In the UK, approximately 25 million t (69%) of municipal waste were landfilled in 2004/05 (Table A7.10). The proportion of waste that had a sort value and recovered by composting, recycling, incineration with energy recovery or any other recovery method, was 26%. This percentage of municipal waste recovery was smaller than the corresponding percentage for England but larger than the other UK countries' recovery rate.

Table A7.10 Amount of MSW landfilled and recovered in the UK in 2004/05

Country	Amount of MSW landfilled (million t) 2003/04	Amount of MSW landfilled (million t) 2004/05	Amount of MSW recovered (million t) 2003/04	Amount of MSW recovered (million t) 2004/05
England	20.9	19.9	7.3	8.1
Wales	1.5	1.5	0.3	0.4
N. Ireland	0.9[1]	0.9	0.1[1]	0.2
Scotland	2.8	2.7	0.5	0.7
UK	**26.1**	**25.0**	**8.2**	**9.4**

Note:
[1]There are no data for the financial year 2003/04 for N. Ireland. The amounts of waste were calculated from the monthly mean tonnage for the calendar years 2003 and 2004.

As the main interests of this research are focused on recycling and composting of household waste, only these two options are discussed further.

A7.4.2 Recycling of municial and household waste

To meet the legislative targets of the UK Government on recycling, rapid improvement in the recycling rate across England is required (Mee *et al.*, 2004). WCAs need to introduce kerbside collection schemes, focusing upon key recyclates, maximise the efficiency of such schemes, and enhance the use of existing civic amenity sites and recycling banks in strategic public places.

A7.4.2.1 'Bring' and 'kerbside collection' systems

The recyclable materials are present in household waste, but unfortunately in a very heterogeneous matrix that makes their segregation one of the major issues in waste recycling. 'Bring' and the 'kerbside collection' systems are the two types of methods to reclaim recyclable materials separately from the household waste stream in the UK. There is a continuous increase in the amount of waste collected by both schemes but their contribution to the overall waste recovery is decreasing after the introduction of kerbside collection of recyclable materials.

'Bring' systems involve the segregation of recyclable materials, such as paper, metals, plastic containers, textiles, shoes, glass bottles, and ink cartridges from household waste by the public and delivery to a centralised collection site. The sites may be bottle and paper banks situated at civic amenity sites for the disposal of a wide range of waste types, the local supermarket or car park, or the local scrap merchant. The collaboration between local authorities, waste management companies, voluntary groups and materials manufacturers is necessary for the operation of bring bank sites. The recommended density for bring banks in the UK is 1 per 750-1000 residents (ETSU, 1998).

The main advantages of such systems are: low capital cost, accessibility, and effective segregation of clean readily marketable materials. However, take up of 'bring' schemes by the public is low. Williams (2002) suggests that the average rates of recovery from bring systems in the UK ranges from 15 to 20%, whilst ETSU (1998) states that the average rates are lower reaching only 6-10%.

The 'kerbside collection' systems involve house to house collection of designated recyclable materials, such as plastic containers, glass bottles, metals, paper, and compostable waste, source-separated by the householder and placed in separate containers or plastic sacks. There is a plethora of kerbside collections schemes across the UK and many of them cover large sections of the population, for example, in Leeds (80,000 households), Milton Keynes (70,000 households), Cardiff (55,000 households), and Falkirk (42,000 households) (Williams, 2002). Despite the high cost of separate collection, the extra costs associated with the sorting of the recyclable materials and transport to the reprocessing facility, and the employment of purpose built vehicles with separate enclosures, the kerbside collection schemes are convenient and popular with the householders.

It is worth noting that in some cases the introduction of kerbside schemes based on statutory weight-based recycling targets which are not material-specific has increased the household waste arisings (Parfitt, 2002). An explanation to this fact could be that the challenge to meet these weight-based recycling targets prioritizes capturing of the heaviest materials in the waste stream such as garden waste through kerbside schemes. For example, a proportion of garden waste collected and incorporated in the total amount of household waste is likely to be material that would otherwise have been dealt with outside the municipal system through home composting or bonfires. Similar experiences have been reported in parts of Germany, where waste arisings have risen sharply following the introduction of garden waste kerbside collections (Sothen *et al.*, 2002).

A7.4.2.2 Household waste recycling in the UK

Household recycling includes materials collected directly from households (kerbside collection), materials taken to Civic amenity (CA) sites and other 'bring' sites provided by the local authority, and materials collected by private and voluntary organisations.

Household waste recycling in England

In England, a total of 4.5 million t, equivalent to 17.7% of household waste was collected for recycling in 2003/04, up from 3.7 million t (14.5%) in 2002/03 (Table A7.11) (DEFRA, 2005). The proportion of households served by kerbside recycling collection schemes has increased consistently between 1996/97 and 2003/04 (Figure A7.6). This proportion has doubled from about a third of households in 1996/97 to four in five households in 2003/04. In the last two years the percentage of household served by kerbside recycling has increased from 67% in 2002/03 to 79% in 2003/04. The amount of waste collected for recycling through such schemes also increased significantly by 52% to 1.9 million t in 2003/04. About half of all responding Local Authorities to DEFRA's survey (96% of total Local Authorities in England) (DEFRA, 2005) indicated that introduced a new kerbside recycling scheme during 2003/04.

The amount of waste collected for recycling from civic amenity and 'bring' sites continued to rise but with a smaller rate of increase compared to previous years. About 2.6 million t of material were collected through these sites in 2003/04, a slight 5% increase over the 2.5 million t collected in 2002/03. The decrease in the rate of increase of household waste collection at civic amenity and bring sites shows that the prevalence of kerbside collection schemes in almost all authorities in England has lessened the necessity for disposal of household waste materials to civic amenity and bring sites.

Since 1996/97 the amount of household waste that is recycled has more than doubled. In 2003/04 an average of 4.1 kg of household waste for recycling was collected per household per week. The household recycling rate has increased from 7.5% in 1996/97 to 17.7% in 2003/04 (Figure A7.7). The increase has been reasonably consistent at about 1 percentage point per year until 2001/2, but since then and for the last three years the rate of increase in recycling has also been increasing.

The provisional waste statistics for 2004/05 (DEFRA, 2006) demonstrate that the amount of household waste collected for recycling has increased from 4.5 million t in 2003/04 to 5.8 million t in 2004/05. The recycling rate of household waste has increased by 4.8 percentage points, rising from 17.7% in 2003/04 to 22.5% in 2004/05. Figure A7.8 shows the changes in household waste and recycling per capita from 1983/84 to 2004/05.

In 2003/04, for the second year running, compostable waste was the most common material collected for recycling with 1.4 million t (30%) of total waste collected (Figure A7.9). The amount of paper and card, which was the most common material recycled until 2002/03, collected for recycling increased to 1.3 million t (28%), followed by glass (0.6 million t, 13%), and scrap metal/white goods (0.5 million t, 10%). In comparison to 2002/03 recycling data, the amounts of all recyclable materials collected have increased: the amount of compostable waste collected for recycling increased by 14%, the amount of paper increased by 13%, glass by 21%, and scrap metal/white goods by 11%. The collection of cans for recycling, both ferrous and aluminium, was also increased by 55%, from 28 million t in 2002/03 to 43 million t in 2003/04. Although cans account for a small proportion by weight (1%) of the total amount of collected materials for recycling, they have a high recovery rate which means that there are particularly strong environmental benefits in recycling them. Larger quantities of co-mingled materials were collected in 2003/04, an increase of 76% compared to 2002/03. The total amount of co-mingled materials collected for recycling is 470,000 t and most common combination of materials is paper/card, cans, plastic and textiles.

Compostable waste was also the most common material collected at civic amenity sites, 37% of total waste collected. The next most common materials collected were scrap metal/white goods (17%), paper/card (16%) and glass (16%). Due to the proliferation of kerbside collection schemes, the amount of paper/card and compostable materials collected at civic amenity sites was reduced by 4% and 3%, respectively. However, there was a 7% increase in glass collection and a 10% increase in scrap metal/white goods.

Of the main types of household materials recycled, paper and card was the only material group in 2003/04 for which more than half the total tonnage (63%) was collected through kerbside collection schemes (Figure A7.10). Conversely, the majority of glass (71%), compostable materials (71%) and scrap metal/white goods (96%) of the households materials collected for recycling, were collected at civic amenity sites. Of the remaining materials, 42% were collected at civic amenity or bring sites, 49% were collected through separate kerbside collections, and 9% through integrated co-collections.

Table A7.11 Municipal waste recycling in 2002/03 and 2003/04 in England (DEFRA, 2005)

	2002/03		**2003/4**	
	million t	**% of total household waste**	**million t**	**% of total household waste**
CA and bring sites	2.5	9.5	2.6	10.1
Separate collection	1.2	4.5	1.8	6.9
Integrated collection	0.1	0.4	0.1	0.5
Voluntary/private collections	<0.05	0.1	<0.05	0.2
Total household recycling	**3.7**	**14.5**	**4.5**	**17.7**
(of which centrally composted)	1.2	4.6	1.4	5.3

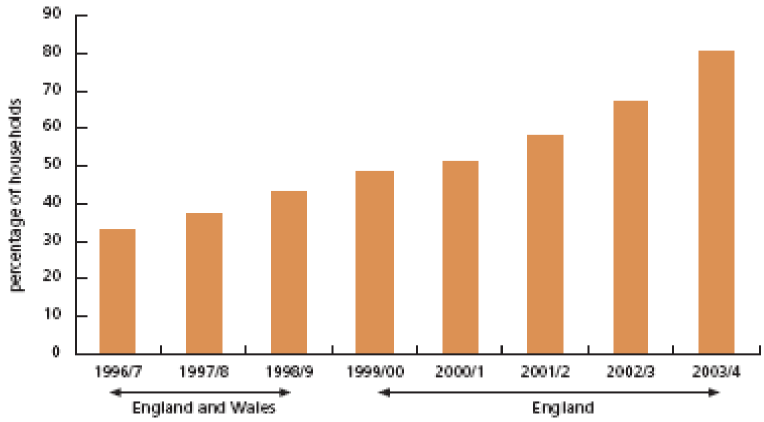


Figure A7.6 Percentage of households served by a kerbside collection scheme 1996/97 – 2003/04 (DEFRA, 2005)

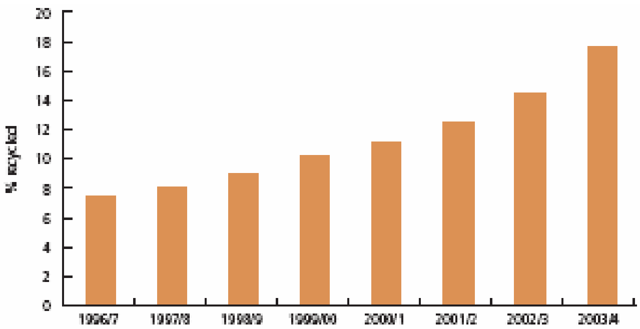


Figure A7.7 Household recycling rates from 1996/97 to 2003/04 (DEFRA, 2005)

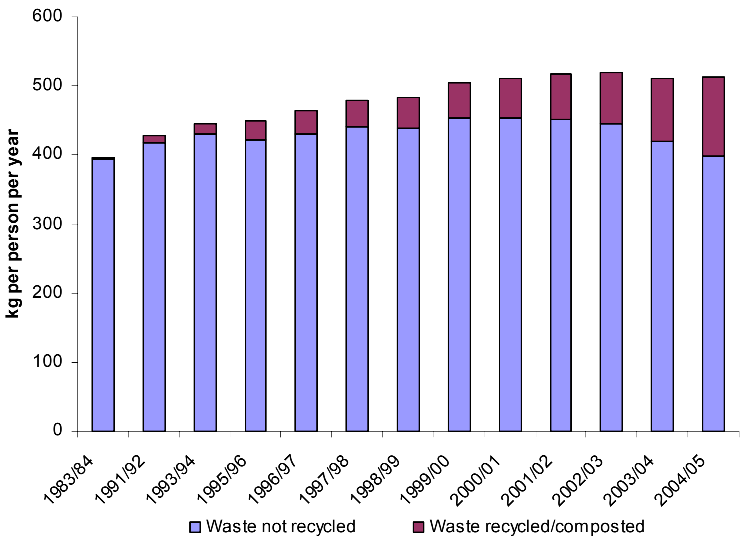


Figure A7.8 Household waste recycled/composted per capita per year in England from 1983/84 to 2004/05 (DEFRA, 2006)

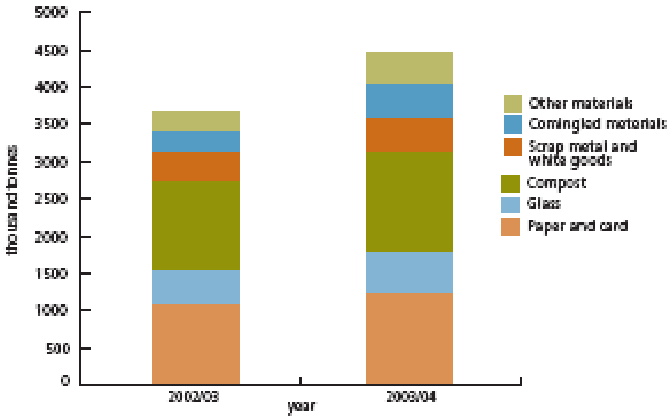


Figure A7.9 Amounts of recyclable materials collected from households in 2002/03 and 2003/04 in England (DEFRA, 2005)

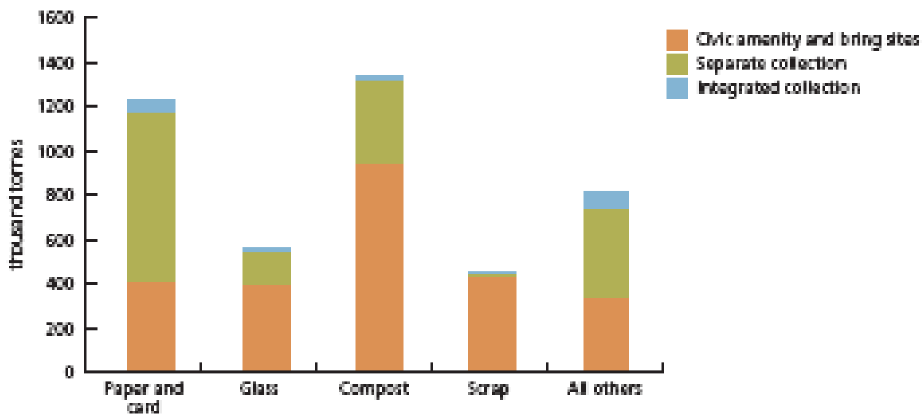


Figure A7.10 Methods of collection for different recyclable materials

In 2003/04, 62% of households received a kerbside collection for two or more recyclable materials in England (Table A7.12). The majority of kerbside schemes carry out collections on a fortnightly basis and in 2003/04, 56% of households had a fortnightly kerbside collection whereas 20% had a weekly collection (Table A7.13). In relation to single material collection only, 65% of households had a dedicated paper and/or card kerbside recycling collection, compostable material was collected from 43% of households, cans from a 41% of households, and glass from 40% of households (Table A7.14). In addition to this, 24% of households received a co-mingled collection, and a large proportion of these collections include some combination of paper, glass and cans.

Table A7.12 Percentage of households served by kerbside collection scheme and number of materials collected (DEFRA, 2005)

Number of materials collected	Percentage of households
2+	62
1	17
0	21

The 830,000 t of paper and card collected through kerbside collections in 2003/04 accounted for about 44% of all materials collected by these schemes (Figure A7.11). The other main materials collected through these schemes were co-mingled collections (23%), compostable waste (21%) and glass (9%). The amount of paper and card collected in kerbside schemes has increased by 25% between 2002/03 and 2003/04, while during the same period the amounts of compostable materials and glass collected have increased by 102% and 79%, respectively. These comparisons relate to single materials collections only. Regarding the co-mingled collections, they have increased by 76%, and most of them include a paper component.

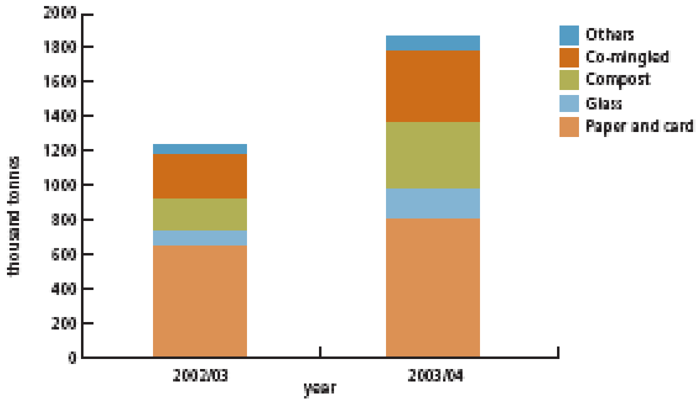


Figure A7.11 Total materials collected for recycling through kerbside schemes: 2002/03 and 2003/04 (DEFRA, 2005)

Table A7.13 Percentage of households and frequency of collections (DEFRA, 2005)

Frequency	Percentage of households
Weekly	20
Fortnightly	56
Monthly	4
None	21

Note:
Includes voluntary collections.
Co-mingled assumed to consist of 3 materials.
'Compost' includes organic materials (kitchen and garden waste) collected for centralised composting schemes from households via kerbside schemes or taken by householders to CA sites. Home composting is not included.
'Co-mingled materials are wastes collected in a mixed form destined for recycling after further sorting, usually in a materials reclamation facility.
'Other' includes oils, batteries, aluminium foil, books and shoes.

There has been a change in the material make up of recycled waste since 1996 (Figure A7.12). In 1996/97 paper and card was the largest component making up 34 % of the total, followed by glass which comprised 19% of the total, whereas compostable materials represented only 17% of recycled waste. In 2003/04, for the second consecutive year, compostable waste was the largest component of household recycling making up 30% of the total, with the next largest component being paper at 28% of the total. Glass currently represents 13% of the total recycled waste. Whilst total recycling has increased from 1.6 million t in 1996/97 to 4.5 million t in 2003/04, the amount of compostable waste collected has increased by a factor of five, rising at an average of 25% per year. Paper and card recycling on the other hand has only increased by an average of 13% per year and glass by

9% per year. Co-mingled collections have become more widespread recently, and 10% of household recycling was collected in this way in 2003/04.

Table A7.14 Percentage of households by material collected by kerbside collection schemes (DEFRA, 2005)

Material	Percentage of households
Paper and card	65
Glass	40
Compost	43
Scrap metal and white goods	18
Textiles	27
Cans	41
Plastics	12
Co-mingled	24
Other	9

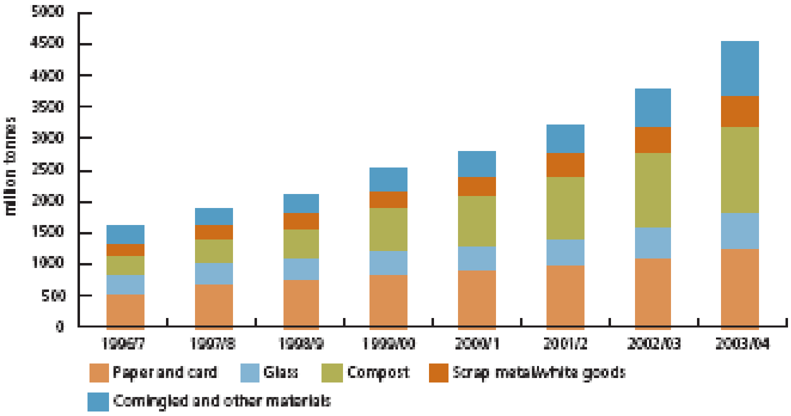


Figure A7.12 Amounts of recyclable materials collected from households in England from 1996/97 to 2003/04 (DEFRA, 2005)

Household waste recycling in Wales
A total of 286,455 t (18%) of household waste was collected for recycling and composting in Wales in 2004/05, compared to 251,651 t (17%) in 2003/04 (The National Assembly for Wales, 2006). Table A7.15 illustrates the quantities of household waste collected at civic amenity sites and through kerbside or other waste collections, and the household recycling/composting rates for each type of waste collection for recycling/composting.

Garden waste was the most common material collected for recycling/composting and accounted for 31% of total household waste recycled in 2004/05 (Table A7.16). The majority of garden waste (56,269 t, 64%) from the total garden waste collected for recycling/composting was transferred to civic amenity sites, while the rest 31,607 t (36%) was collected through kerbside collection. The next most common material collected for recycling/composting was paper and card with 26% of total household waste recycled and most of it was collected through kerbside collection (48,355 t, 64%). As with waste statistics for England in 2003/04, the amounts of compostable and paper/card that are collected for recycling/composting at civic amenity and bring sites are falling in Wales due to the increased provision of kerbside schemes collecting these materials. Packaging glass made up 13% of total household waste collected for recycling/composting in 2004/05 and it was collected at approximately equal quantities through both types of collection.

Table A7.15 Household waste recycling/composting in Wales in 2003/4 and 2004/05 (The National Assembly for Wales, 2006)

	2003/04		2004/05	
Type of collection[1]	**Quantity (t)**	**% of total household waste**	**Quantity (t)**	**% of total household waste**
CA and bring sites	165,617	10.9	164,668	10.4
Kerbside collection[2]	79,685	5.2	121,218	7.6
Other collections[3]	6,349	0.4	569	0.0
Total	**251,651**	**16.5**	**286,455**	**18.1**

Notes:
1. Non-household recycling/composting (including rubble materials) is excluded.
2. Includes data from 2003/04 classed as ‘co-collection’.
3. ‘Other collections’ include private and voluntary collections not covered in other headings.

Table A7.16 Amounts of recyclable materials from household sources collected for recycling/composting in 2003/04 and 2004/05 by scheme type (The National Assembly for Wales, 2006)

	Kerbside collection (t)		CAs and bring sites (t)		Voluntary/private collection (t)		Total household waste recycled/composted (t)	
Material	**2003/04**	**2004/05**	**2003/04**	**2004/05**	**2003/04**	**2004/05**	**2003/04**	**2004/05**
Dense plastic bottles	1,398	3,340	270	700	106	0	1,774	4,041
Ferrous food&beverage cans[1]	1,674	3,685	928	1,046	19	0	2,620	4,731
Garden waste	23,299	31,607	70,015	56,269	0	0	93,314	87,877
Non-ferrous metals[2]	77	154	36	41	0	0	113	194
Other ferrous metals	918	695	19,024	22,107	0	0	19,942	22,802
Packaging glass	10,181	18,544	17,784	18,704	2,174	0	30,138	37,248
Textiles and shoes	700	703	3,080	2,713	183	319	3,962	3,735
Wood	0	427	11,777	24,972	75	0	11,852	25,399
Food[3]	..	..	..	..	..	..	..	..
WEEE[4]	1,039	1,454	9,093	6,721	2	0	10,134	8,175
Paper and card	32,904	48,355	28,856	27,454	1,428	54	63,189	75,862
Miscallaneous	7,495	12,254	4,755	3,941	2,362	197	14,611	16,392
Total	**79,685**	**121,218**	**165,617**	**164,668**	**6,349**	**569**	**251,651**	**286,455**

Notes:
[1]Includes mixed cans.
[2]Includes scrap metal.
[3]Where ‘..’ is indicated, there is no data for the separate collection of food waste.
[4]Waste Electronic and Electrical Equipment.

Figure A7.13 depicts the differences in tonnage of the materials collected for recycling/composting between 2003/04 and 2004/05. Garden waste decreased by 6%, from 93,314 t in 2003/04 to 87,877 t in 2004/05. This reduction may be associated with an increase in home composting due to the widespread distribution of compost bins by the majority of local authorities in Wales. WEEE and textiles and shoes were the other two categories of waste that decreased by 19% and 9%, respectively.

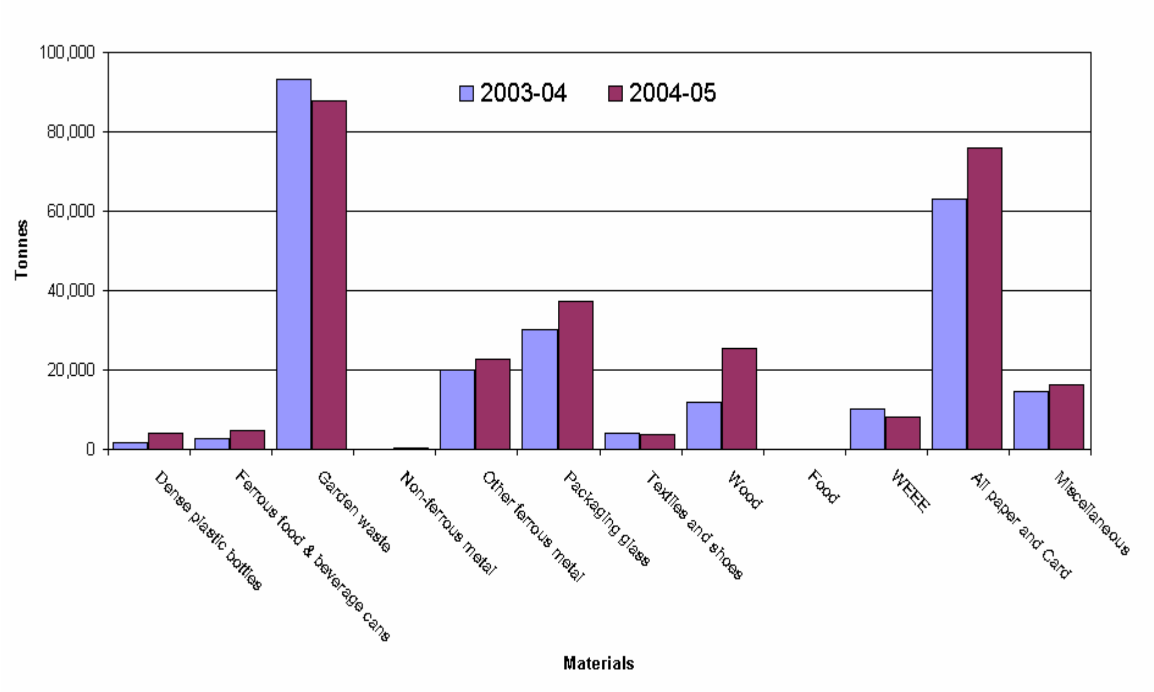


Figure A7.13 Amounts of different materials recycled/composted from households in Wales in 2003/04 and 2004/05 (The National Assembly for Wales, 2006)

Household waste recycling in Northern Ireland

The total amount of municipal waste that was either recycled or composted in Northern Ireland in 2004/05 was 191,197 t (18.2%) and it is expected to rise to 245,521 t (23.09%) in 2005/06 (Environment and Heritage, 2005; Environment and Heritage, 2006). Household waste was recycled and composted at a rate of 18.9% (173,456 t) in 2004/05 and there is a provisional increase to 24.6% (938,196 t) in 2005/06.

Owing to a delay in the completion of the final report for the waste statistics in Northern Ireland for 2004/05, the amounts of household waste collected for recycling and composting through kerbside collection or at civic amenity and bring sites have not been published yet. This delay is attributed to the fact that 2004/05 was the first financial year that the Environment and Heritage Service compiled waste statistics for Northern Ireland instead of two calendar years by using the WasteDataFlow spreadsheets. However, these data were obtained from the Department of the Environment for Northern Ireland by personal communication with Dr A. Fitzpatrick (Table A7.17). In 2004/05, the majority of household waste collected for recycling or composting (63%) came from civic amenity sites, followed by kerbside collection schemes (32.5%). The composition of the recyclable waste collected through kerbside collection and at civic amenity and bring sites in 2004/05 is currently not accessible and cannot be presented in this report, but it is available for the calendar years 2003 and 2004 (Table A7.18).

Table A7.18 shows that the amount of not mixed paper that was recycled through kerbside collection schemes was 6,126 t in 2003 and more than doubled in 2004 (13,024 t). The materials collected by co-mingled kerbside collections increased dramatically from 6,114 t in 2003 to 19,946 t in 2004. The tonnage of compostable materials that were collected from households for composting in 2004 (13,719 t) was about twice as much the tonnage of such waste collected in 2003 (7,670 t). The total amount of recyclates and compostable materials collected through kerbside collection for recycling and composting doubled in one year's time, from 26,398 t in 2003 to 52,864 t in 2004, which emphasises the latest expansion of kerbside recycling schemes in Northern Ireland. The materials that were transferred to civic amenity and bring sites for recycling or composting increased by 27.4%, from 91,311 t in 2003 to 116,302 t in 2004. Although the materials at bring sites were collected at approximately equal quantities in both years, there was an increase of 29.5% in the materials collected for recycling and composting at civic amenity sites. In 2004, the amount of recyclates collected at such sites increased by 34.1% and compostable materials increased by 25.0%. The increase in recyclable and compostable waste collected at civic amenity and bring sites contradicts the trend occurring in the other UK countries, where there was a decrease.

Household waste recycling in Scotland

A total of 298,683 t of waste collected by, or on behalf of, Scottish local authorities was recycled during 2003/2004 (SEPA, 2006). This total was made up of 282,765 t of waste collected for recycling plus an additional 16,625 t of waste originally collected for disposal but actually recycled. Of the waste collected for recycling, 707 t had to be sent for disposal because either there was no market for the recyclate or contamination had made the waste unfit for recycling.

Recyclables were mainly collected through bring collection schemes (including the 166 civic amenity sites operating across Scotland) and kerbside schemes. A total of 147,717 t was collected at bring sites and 98,767 t by kerbside collections. In addition, 31,565 t were recovered at material recycling facilities (MRFs) and 20,631 t were recovered by other methods. Figure A7.14 (a) and (b) show the breakdown of Scottish local authority recycling in 2003/2004 by material. Figure A7.14 (a) shows those materials where the weight recycled exceeded 5,000 t and (b) shows those where the weight was less than 5,000 t.

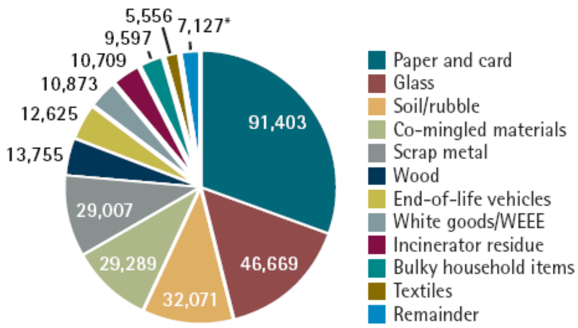
In 2003/2004, all local authorities had a bring recycling collection scheme operating in their area. Of the total 32 local authorities in Scotland, 28 reported that they had a kerbside recycling collection scheme for household waste which was offered to 1.11 million households (equivalent to 47% of all households in Scotland).

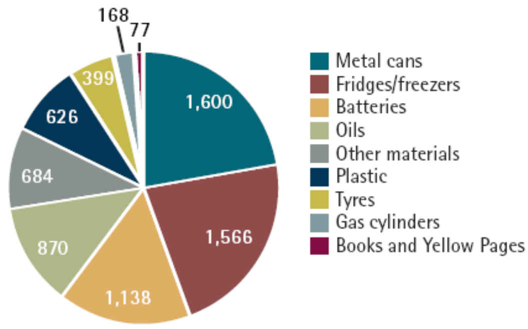
Table A7.17 Amounts of household waste collected for recycling/composting in 2004/05 by method of collection (Environment and Heritage service, 2006)

Household waste category	Quantity (t)	% of total household waste
CA sites	109,432	63.0
Bring recycling schemes	6,706	4.0
Kerbside collection	56,491	32.5
Other collections	826	0.5
Total household waste recycling/composting	**173,456**	**100**

Table A7.18 Composition of household waste collected for recycling/composting in 2003 and 2004 by method of collection (Environment and Heritage service, 2006)

	Kerbside collection				CA and bring sites (t)			
	Integrated household collection (t)		Separate household collection (t)		Recycling only (t)		Other bring recycling schemes (t)	
Material	**2003**	**2004**	**2003**	**2004**	**2003**	**2004**	**2003**	**2004**
Glass	0	0	617	1,602	4,095	4,417	3,185	3,206
Paper (not mixed)	0	0	6,126	13,024	4,548	3,695	850	1,014
Card (not mixed)	0	0	93	1	2,736	3,708	235	132
Mixed paper and card	1,028	0	3,992	2,655	2,306	1,600	814	838
Steel cans	0	0	137	119	0	0	0	1
Aluminium cans	0	0	20	46	18	8	2	7
Mixed cans	97	0	54	284	75	87	126	60
Plastics	325	0	313	698	454	993	123	297
Textiles	0	0	86	126	742	1,348	468	663
Wood	0	0	0	0	4,268	9,733	0	20
Oil	0	0	0	0	305	305	7	78
Vegetable oil	0	0	0	0	5	155	0	0
Scrap metal	0	0	225	185	10,049	10,772	73	8
White goods	0	64	212	299	1,172	1,654	109	46
Fluorescent lights	0	0	0	0	3	53	0	0
Car batteries	0	0	0	0	164	460	0	0
Abandoned vehicles	0	0	0	0	0	0	0	0
WEEE	0	0	5	0	230	729	0	50
Tyres	0	0	0	0	8	70	0	0
Co-mingled	2,435	3,884	6,114	19,946	0	5	43	406
Consruction&demolition	0	0	0	0	10,479	14,327	546	0
Other	0	0	736	159	40	1,792	35	0
Sub-total	3,886	3,948	18,728	39,145	41,697	55,912	6,616	6,826
Compostables	0	0	7,670	13,719	42,579	53,217	419	347
Total	**3,886**	**3,948**	**26,398**	**52,864**	**84,276**	**109,129**	**7,035**	**7,173**





(a) **(b)**

Figure A7.14 Breakdown of different materials collected for recycling in t (a) Total weight recycled >5,000 t (b) Total weight recycled <5,000 t (SEPA, 2006)

A7.4.3 Composting of household biodegradable waste

Recent studies indicate that at least 60% of MSW is biodegradable (Parfitt and Flowerdew, 1997; EA, 2004), which means that currently in the UK the biodegradable fraction of MSW is equivalent to approximately 21.7 million t of material. Biodegradable waste is defined by the Landfill Directive as 'waste that is capable of undergoing aerobic or anaerobic decomposition, such as food and garden waste, and paper and cardboard' (EC, 1999). Composting is widely regarded as the most appropriate processing option for biodegradable household waste. The significance of composting consists in the simplicity of the composting process and its effectiveness to diminish the adverse impacts of landfilling biodegradable waste.

Composting is a natural aerobic biochemical process capable of converting biodegradable waste into a beneficial residue termed compost. It is carried out by a complete ecology of decomposing microorganisms, such as bacteria and fungi, which are particularly important during the rapid, active stage of the composting process. Larger organisms, including insects and earthworms, break down less easily degradable materials in the later stages of the process. The organisms responsible for composting consume organic materials and oxygen in order to grow and reproduce. In the process, they produce carbon dioxide, water vapour, and heat (Figure A7.15). The overall biochemical equation that takes place during the composting process can be written:

$$\text{Organic matter} + O_2 + \text{Aerobic bacteria} \rightarrow \text{Compost} + CO_2 + H_2O + \text{Heat}$$

In 2003/04, 1.4 million t of green waste was collected for composting in England representing a 14% increase over 2002/03 (Figure A7.16) and amounting to about 5.3% of total household waste. The majority of household waste collected for composting in 2003/04 came from civic amenity and bring sites (71%) but this proportion is slowly falling, as it was 84% in 2002/03. This fall is due to the introduction or expansion of kerbside collection schemes to capture compostable waste.

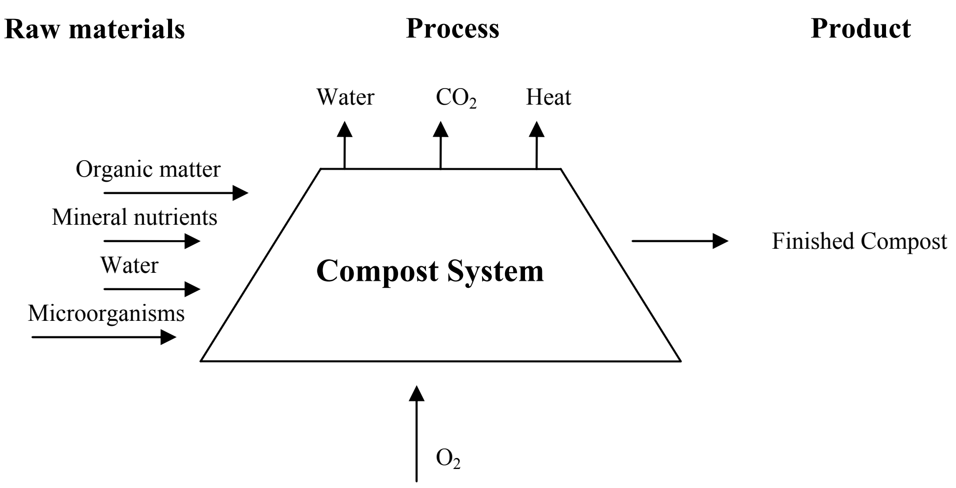


Figure A7.15 The composting process

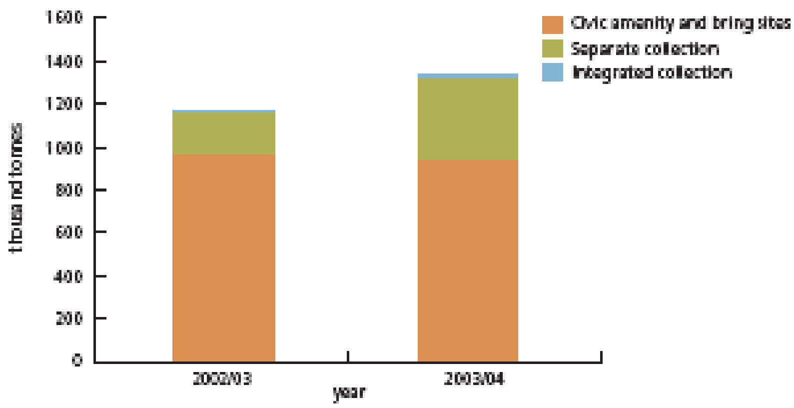


Figure A7.16 Compostable waste collected through different schemes for household waste: 2002/03 and 2003/04 (DEFRA, 2005)

Regarding the amounts of waste composted in all UK countries, the Composting Association (The Composting Association, 2005) has conducted a number of surveys assessing the state of composting in the UK since 1994. The latest survey was carried out for the financial year 2003/04 and distributed to a total of 474 local authorities and 410 compost producers. It attained an overall response rate of 43% (49% response rate for local authorities and 36% of composting operators). According to this survey, the quantity of municipal waste composted in the UK has continued to grow steadily over recent years (Figure A7.17). The majority of municipal wastes composted were sourced from households, representing 1.44 million t of the total 1.97 million t composted in the UK in 2003/04. Green waste collected from civic amenity sites was the main source of waste, accounting for the three-quarters of municipal wastes composted and over half of the total composted in the UK (Table A7.19).

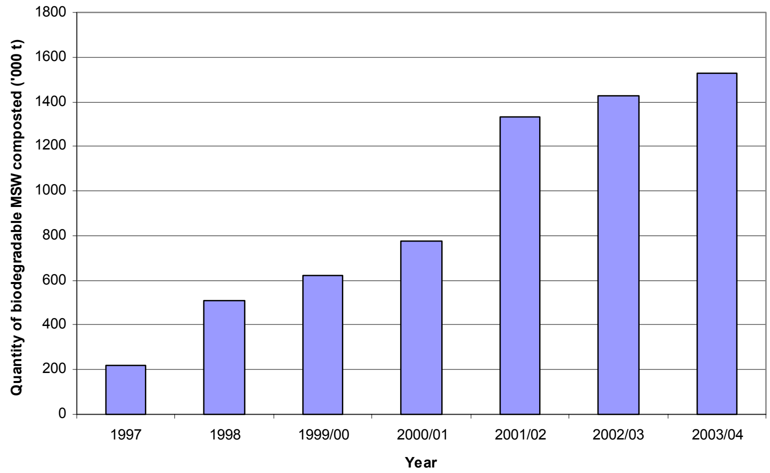


Figure A7.17 Growth of MSW composting in the UK based on the total quantity of waste processed per year (The Composting Association, 2005)

Table A7.19 Quantities and types of feedstock processed in the UK (The Composting Association, 2005)

Waste type	Input quantity ('000 t)	Category percentage (%)	Total percentage (%)
Garden from CA/bring sites	1,070	74.1	54.2
Garden only from kerbside collections	309	21.4	15.7
Garden and kitchen from kerbside collections	49	3.4	2.5
Kitchen waste only	2	0.2	0.1
Other	13	0.9	0.7
Total municipal household waste	**1,443**	**100.0**	**73.1**
Total municipal non-household waste	82	_	4.2
Commercial (non-municipal)	447	_	22.7
Total composted	**1,972**	_	**100.0**

Compost is an effective soil conditioner, mulch, and topdressing for improving soil quality, plant growth, moisture retention and weed suppression. Compost addition increases nutrient and moisture retention in sandy soils, while in heavy clay soil, compost particles bind with clay particles to form loose aggregates increasing drain age and resistance to surface crusting and erosion. Compost contains minor and major plant nutrients which are slowly released for plant uptake over several growing seasons. Annual or regular additions of compost increase the organic matter and fertility level of soil and sustain long-term soil productivity.

The British Standards Institution (BSI) has published the British Standard PAS 100 which specifies the minimum requirements for the selection of input materials, process of composting and the quality of composted materials, as well as for the marking and information labelling of the product (The Composting Association, 2003). The objective of the

PAS 100 is to improve confidence in composted materials among end users, specifiers and blenders differentiate products that are safe, reliable and high performance.

A7.4.3.1 Bioprocesses in composting

Composting is a complex process based on the growth and activity of a wide array of microbial populations. According to temperature patterns, the composting process can be divided into four different stages (Finstein and Morris, 1974; Strom, 1985a; Day and Shaw, 2000), summarised in Table A7.20.

Initial decomposition of organic matter is carried out by mesophilic microorganisms, which break down the soluble, readily degradable compounds and produce heat rising rapidly the temperature in the composting pile. When temperature is in the 35 to 45°C range, the microbial activity is prodigious (Burford, 1994; Finstein, 1992 and McKinley *et al.*, 1985). As the temperature rises past 45°C, conditions are less favourable for the mesophilic microbial populations and the thermophilic microorganisms predominate in the composting process. During the thermophilic phase, high temperature accelerates the breakdown of proteins, fats, and complex carbohydrates like cellulose and hemicellulose, which are the major structural molecules in plants. As the supply of these high-energy compounds becomes exhausted, the compost temperature gradually decreases and mesophilic microorganisms once again take over for the final phase of "curing" or maturation of the remaining organic matter. Microbial activity is low during this stage, which can last a few months.

The temperature profile of the composting process can be more or less complex, depending on the case of the composting application, but a typical temperature profile could be represented as a simple curve (Figure A7.18). Initially, the temperature increases rapidly to approximately 60°C, where it briefly plateaus. After that, the temperature begins to decrease, and gradually becomes ambient.

The microorganisms that are mainly responsible for the composting process are fungi, actinomycetes, and bacteria, possibly also protozoas and algae (Day and Shaw, 2000). The microbial population of bacteria, fungi, and actinomycetes changes during composting, following the changes in temperature. The changes obtained during the windrow composting of biosolids and bark are shown in Figure A7.19 (Epstein, 1997; Walke, 1975).

Table A7.20 Phases of composting process (Finstein and Morris, 1974; Strom, 1985a)

Phase	Microorganisms	Phase description	Temperature °C
Latent (Cryophilic)	Psychrophiles /Cryophiles	At low temperatures, microorganisms acclimatize and colonize environment in the compost pile.	5-10
Microbial growth (Mesophilic)	Mesophiles	Abundance of substrate ensures that high activity of microorganisms, leading to greater generation of metabolic heat energy, which causes the temperature of the compost pile to increase.	15-45
Thermophilic	Thermophiles	Temperature rises to the highest level. Waste stabilization and pathogen destruction are most effective. Efficiency and speed begin to drop abruptly particularly at temperatures in excess of 70°C as spore-formers begin to lose their vegetative forms and assume spore forms during which little activity occurs.	50-70
Curing/Maturation	Mesophiles and psycrophiles	During the maturation phase, the low amount of readily available nutrients determines a reduction in the microbial activity and consequently in the production of heat. This phase allows further stabilization, reduction of pathogens and decomposition of cellulose and lignin.	10-30

According to Finstein and Morris (1974) bacteria thrive during all the stages of composting. Poincelet (1977), who analysed the microbial population a function of temperature, found that bacteria are usually present in large numbers throughout the whole composting period and are the major microbial species responsible for the degradation processes (Table A7.21). As shown in this table, in most cases, bacteria are about 100 times more prevalent than fungi. Golueke (1977) estimated that at least 80 to 90% of the microbial activity in composting is due to bacteria. Actual bacteria populations are dependent upon the feedstock, local conditions, and amendments used. Burford (1994) observed that at the start of the composting process a large number of species are present including *Streptococcus* sp., *Vibrio* sp., and *Bacillus* sp. with at least 2000 strains. Corominas *et al*. (1987), in his study of microorganisms in the composting of agricultural wastes, identified species belonging to the genera *Bacillus, Pseudomonas, Arthrobacter*, and *Alcaligenes,* all in the mesophilic stage. In the thermophilic stage, Strom (1985b) identified 87% of the thermophilic bacteria to be of the *Bacillus* sp. such as *B. subtilis, B. stearothermophilus*, and *B. licheniformis* . However, colony variety has been found to decrease as the temperature increases (Carlyle and Norman, 1941; Finstein and Morris, 1974).

Actinomycetes belong to the order Actinomycetales. Although they are similar to fungi, in that they form branched mycelium (colonies), they are more closely related to bacteria. Usually they are not present in appreciable numbers until the composting process is well established. Visual growth of actinomycetes may be observed under favourable conditions, usually between 5 to 7 days into the composting process (Finstein and Morris, 1974; Golueke, 1977). When present in a composting process they can be readily detected due to their greyish appearance spreading throughout the composting pile. Species of the actinomycetes genera *Micromonospora*, *Streptomyces*, and *Actinomyces* can regularly be found in composting material. These species can be spore formers and are able to withstand adverse conditions, such as inadequate moisture. Because the actinomycetes can utilize a relatively wide array of compounds as substrates, they play an important role in the degradation of the cellulosic component. To some extent they can also decompose the lignin component of wood (Golueke, 1977).

More types of fungi have been identified in the composting process than either the bacteria or actinomycetes. Kane and Mullins (1973a) identified 304 unifungal isolates in one batch of compost in a solid waste reactor composting system in Florida. Two general growth forms exist in fungi; molds and yeasts. The most commonly observed species of cellulolytic fungi (Bhardwaj, 1995) in composting materials are *Aspergillus, Penicillin*, *Fusarium, Trichoderma,* and *Chaetomonium*. While cellulose and hemicellulose are slower to degrade than either sugars or starches, lignin is the most resistant organic waste and as such is usually the last in the food chain to be degraded (Epstein, 1997). However, the *Basidiomycetes*, or white rot fungi, play a very important role in the degradation of lignin.

The upper limit for fungal activity seems to be around 60°C. This inactivity of the mesophilic and thermophilic fungi above 60°C has been reported by Chang and Hudson (1967), Finstein and Morris (1974), Gray (1970), and Kane and Mullins (1973b). However, at temperatures below 60°C, the thermophilic fungi can recolonise the compost pile. At temperatures below 45°C, the mesophilic fungi reappear. One of the few thermophilic fungi that survive above 60°C is the thermotolerant species *Aspergillus fumigatus* (Haines, 1995). The spores of this species readily withstand temperatures above 60°C and this species becomes the dominant fungus in the compost pile at those temperatures. *Aspergilllus fumigatus* is a mold and has a special significance as a cellulose and hemicellulose degrader (Fischer *et al*., 1998). However, the air borne spores can be a health hazard at the composting facility, to site workers who have a history of respiratory illnesses (Olver, 1994).

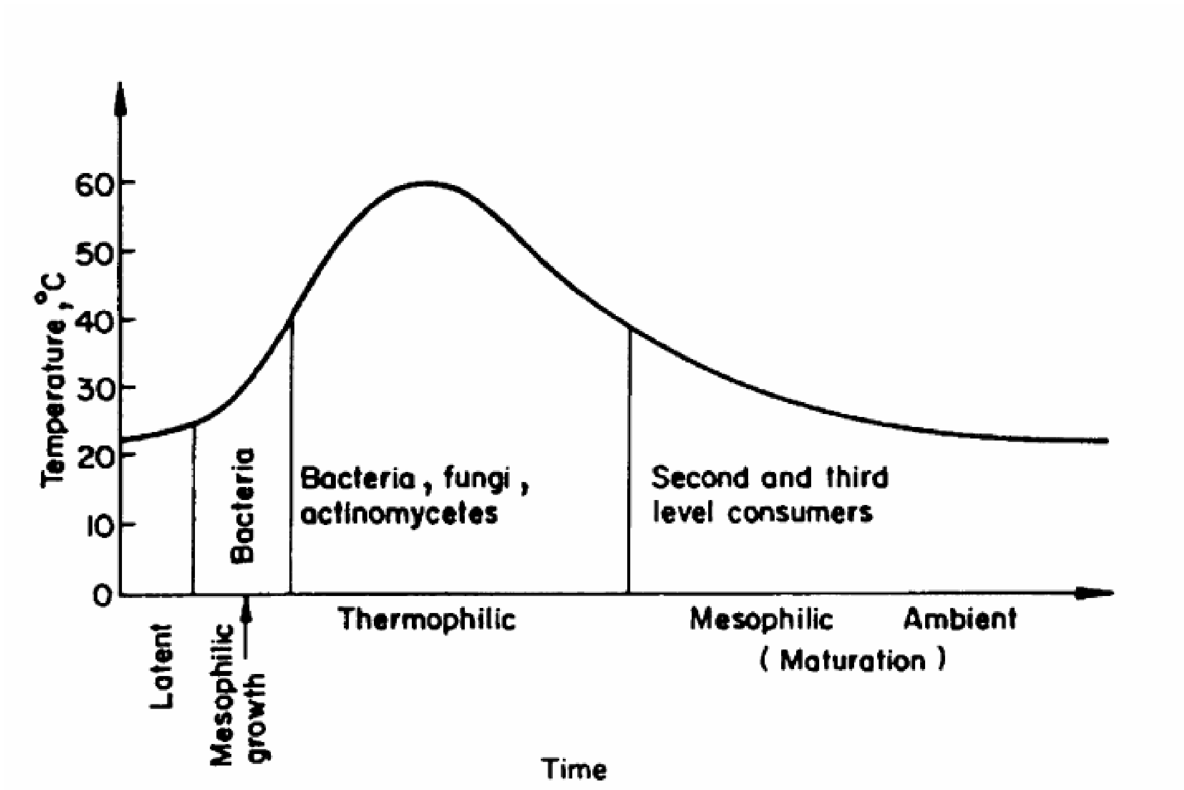


Figure A7.18 Temperature profile and microbial growth during the composting process (Polpresert, 1989; Day and Shaw, 2000)

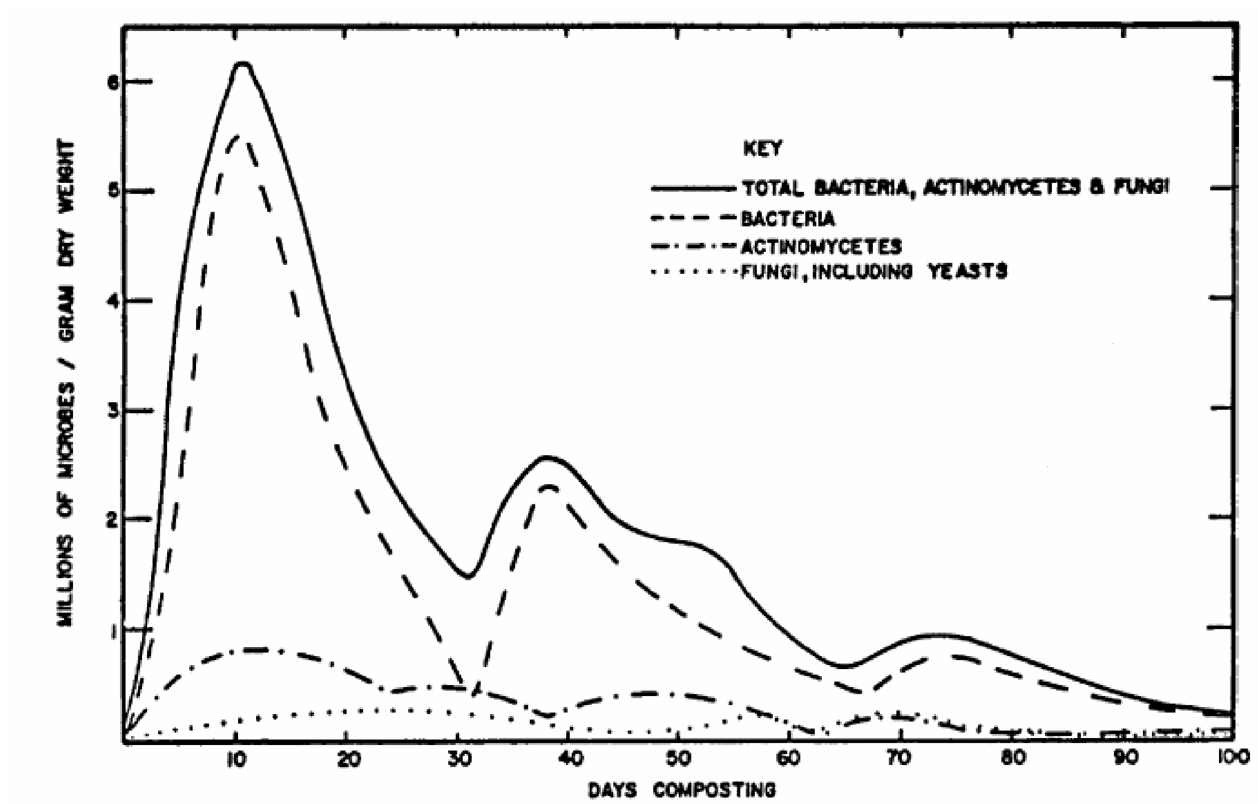


Figure A7.19 Fluctuation of microbial population in windrow during composting (Walke, 1975)

Table A7.21 Microbial population during composting (Poincelet, 1977)

Microbe	Mesophillic initial temperature <40°C	Thermophillic 40-70°C	Mesophillic 70°C to cooler	No. of species identified
		Bacteria		
Mesophillic	10^8	10^6	10^{11}	6
Thermophillic	10^4	10^9	10^7	1
		Actinomyces		
Thermophillic	10^4	10^8	10^5	14
		Fungi[a]		
Mesophillic	10^6	10^3	10^5	18
Thermophillic	10^3	10^7	10^6	16

Notes:
Number of organisms are per g of compost.
Composting substrate not stated but thought to be garden type material composted with little mechanical agitation.
[a]Actual number present is equal to or less than the stated value.

A7.4.3.2 Environmental factors affecting the composting process

Moisture
The moisture content of compost is a critical criterion for optimum composting (Wiley, 1957). Optimum moisture values for a wide range of organic wastes were summarised by Jeris and Regan (1973a) with values ranging from 25 to 80%. However, it appears that moisture contents between 50 and 60% are most desirable (Bhardwaj, 1995; Golueke, 1989; Hachicha *et al*., 1992; Hamoda *et al*., 1998; McGaughey and Gotass, 1953; Miller, 1989; Neto *et al*., 1987; Poincelet, 1977; Stentiford, 1996). Water is essential for bacterial activity in the composting process (the nutrients for the microorganisms must be dissolved in water before they can be assimilated) (Fricke and Vogtmann, 1993; Hamoda *et al*., 1998). A minimum moisture content of 12 to 15% is essential for bacterial activity (Miller, 1989). However, even at levels of 45% or below, the moisture level can be rate limiting (Golueke, 1989; Jeris and Regan, 1973b; McGaughey and Gotass, 1953; Poincelet, 1977; Richard, 1992; Stentiford, 1996) causing composting facility operators to prematurely assume that their compost process has stabilised (Richard, 1992; Stentiford, 1996). On the other hand, excessive moisture in compost will prevent O_2 diffusion to the organisms, resulting in the material going anaerobic with the potential for odour formation (Golueke, 1989; Hamoda *et al*., 1998; McGaughey and Gotass, 1953; Poincelet, 1977; Wiley, 1957). Compost with too high a moisture content can also result in loss of nutrients and pathogens to the leachate, in addition to causing blockage of air passageways in the pile (Polprasert, 1989). Although moisture levels between 50 and 60% are generally accepted as optimum, detailed experiments performed by Snell (1957) suggested that for domestic garbage the range for optimum composting could be narrowed to between 52 to 58%. Suler and Finstein (1977) observed 60% to be the ideal moisture value for composting of food waste.

Moisture in compost comes from two sources: moisture in the initial feedstock, and metabolic water produced by microbial action. Theoretical calculations by Finstein *et al*. (1983), Haug (1993), and Naylor (1996) suggest that between 0.6 and 0.8 g of water can be produced per g of decomposed organic matter during composting. Experimental results suggest that the value is closer to 0.55 to 0.65 g per g of organic material (Griffin, 1977; Wiley *et al*., 1955). However, the aerobic decomposition of 1 g of organic matter releases approximately 25 kJ of heat energy, which is enough to vaporise 10.2 g water (Finstein *et al*., 1986). Thus there is a tenfold excess of energy for water vaporisation, which when coupled with losses due to aeration (Naylor, 1996) accounts for the major loss of water during composting. Typically, a compost operator would aim for an initial moisture content of about 60%, which during composting will decrease to about 40% to facilitate downstream processing such as sieving, mixing, and bagging (Fricke and Vogtmann, 1993).

Oxygen

Composting is an oxidation process where O_2 is consumed and CO_2 is produced. Oxygen (O_2) is essential for the metabolism and respiration of aerobic microorganisms, and for the oxidization of organic matter waste material. During the different stages of the composting process, oxygen requirements vary but demand is greatest during the initial and thermophilic stages because of the rapid expansion of the microbial population and a high rate of biochemical activity. As microbial activity progresses, CO_2 concentration increases and the O_2 concentration falls. Oxygen demand is lower during mesophilic stabilisation and decreases further through the maturation stage. Based upon several controlled tests it would appear that typical O_2 utilisation rates for composting at 50 to 70°C are within the range of 1 to 10mg O_2/g/h (Strom, 1985a).

Nutrients

Carbon (C) and Nitrogen (N)

The elemental composition of the material processed at a composting operation very much dependent upon the types of feed materials being processed. However, both C and N are essential to the composting process. Carbon provides the primary energy source, and N is critical for microbial population growth. For effective and efficient composting, the correct C:N ratio is essential. Although various organic feedstocks have been successfully composted with C:N ratios varying from about 17 to 78 (McGaughey and Gotass, 1953; Nakasaki *et al*., 1992), a much narrower range of between 25 to 35 is considered desirable (Hamoda *et al*., 1998; Keller, 1961; Schulze, 1962). Table A7.22 provides data for the C and N composition of a wide variety of possible compost feedstocks derived from a variety of reference sources. The concern at low C:N ratios is the loss of ammonia (NH_3) (Morisaki *et al*., 1989), but at higher levels slow rates of decomposition can be anticipated (Finstein and Morris, 1974).

Table A7.22 Carbon and Nitrogen composition of some compost feedstocks

Feedstock	C (%)	N (%)	C/N ratio	Reference
Urine	12.1	15.1	0.8	Polprasert, 1989
Fish scraps	32.8	8.2	4.0	Mattur, 1991
Activated sludge	35.3	5.6	6.3	Poincelet,1977
Grass	41.6	2.46	17.0	Michel *et al.,* 1993
Cow manure	30.6	1.7	18.0	Polprasert, 1989
Food waste	50.0	3.2	15.6	Kayhanian and Tchobanoglous, 1992
Yard waste	44.5	1.95	22.8	Kayhanian and Tchobanoglous, 1992
Leaves	44.5	0.93	48.0	Michel *et al.,* 1993
Paper	43.3	0.25	173	Savage, 1996
Cardboard	48.2	0.20	254	Day *et al.,* 1998
Sawdust	56.2	0.11	511	Wilson, 1993

Although the starting C:N ratio is important for effective and efficient composting, the final value is also important to determine the value of the finished compost as a soil amendment for growing crops. In general, a final C:N ratio of 15 to 20 is usually the range aimed for (Kayhanian and Tchobanoglous, 1993), although a value of 10 (Mathur, 1991) has been suggested as ideal. A final compost with a C:N ratio greater than 20 should be avoided since it could have a negative impact on plant growth and seed germination (Golueke, 1977). However, it is the availability of the C that is important, not the total measured C, so composts with C:N ratios higher than 20 can be acceptable when the C is not readily available (McGaughey and Gotass, 1953).

Phosphorus (P)
Other chemical elements present in compost feedstocks can influence the composting process, the quality of the compost produced, and the general acceptance of the composting process. Although compost feedstocks must have C and N to provide the fundamental nutrients to the living organisms for the composting process, phosphorus (P) is also an essential element especially in composting MSW (Brown *et al*., 1998). Although feedstocks such as biosolids, yard debris, and agriculture wastes may have sufficient P, MSW (because it is high in cellulose) may not have sufficient P for effective composting. The quantities of P along with N and potassium (K) present in the final material also are important in determining the quality of the compost product because they are essential nutrients for plant growth. Although not as critical as the C:N ratio, a C:P ratio of 100 to 200 seems to be desirable (Howe and Coker, 1992; Mathur, 1991). Phosphorus composition and the C:P ratio can vary widely depending upon the source of the feedstocks (Table A7.23).

Table A7.23 Carbon and phosphorus composition of various feedstocks

Feedstock	C (%)	P (%)	C/P ratio	Reference
Grass	41.6	0.26	160	Michel *et al.,* 1993
Leaves	44.5	0.05	890	Michel *et al.,* 1993
Leaves	49.9	0.2	250	Polprasert, 1989
Mixed paper	48.9	0.05	978	Kayhanian and Tchobanoglous, 1992
Yard waste	43.1	0.07	700	Kayhanian and Tchobanoglous, 1992
Food waste	44.6	0.08	557	Kayhanian and Tchobanoglous, 1992
Liquid sludge	41.4	0.17	244	Neto *et al.,* 1987
Poultry manure/peat	42.7	0.90	47	Fernandes and Sartaj, 1997

Sulphur (S)
Sulphur concentrations are not usually measured in most scientific investigations of the composting process, but the presence of S in sufficient quantities can lead to the production of volatile, odorous compounds detectable at low level concentrations (Day *et al*., 1998; Toffey and Hentz, 1995). The major sources of S in compost materials are the two amino acids cysteine and methionine found in protein materials.

Particle size
Another physical property of importance to the compost process is particle size. This not only affects moisture retention (Jeris and Regan, 1973a) but also the free air space (Jeris and Regan, 1973a; Schulze, 1961) and porosity of the compost mixture (Naylor, 1996). Large particle size materials result in increased free air space and high porosity, but smaller particles result in the reverse effect. However, because aerobic decomposition occurs on the surface of particles, increasing the surface to volume ratio of the particles by decreasing particle size increases composting activity (Gotass, 1956; U.S. EPA, 1971; Willson, 1993). Consequently a compromise in particle size is required, with good results reported with material ranging in size from 3 to 50 mm in diameter (Gray and Biddlestone, 1974; Hamoda *et al*., 1998; Haug, 1993; Snell, 1991; Willson, 1993). The ideal free air space for optimum composting has been estimated to be 32 to 36% (Epstein, 1997). Jeris and Regan (1973a)

calculated this range from field studies using a variety of materials with different densities and particle sizes, where the relationship between free air space, moisture, and O_2 consumption was determined. Fermor (1993) determined a similar value of 30%.

Compaction can also influence the free air space, although free air space is related to particle size. Any form of compaction that will reduce the free air space will reduce air permeably and increase resistance to air flow (Singley *et al*., 1982). In view of the importance of particle size distribution, compost operators usually employ grinding and sieving equipment to achieve material of the desired size for easier handling and processing (McGaughey and Gotass, 1953; Poincelet, 1977; Richard, 1992; Savage, 1996) when dealing with oversize wastes.

pH

Although the composting process is relatively insensitive to pH, because of the wide range of organisms involved (Epstein *et al*., 1977), the optimum pH range appears to be 6.5 to 8.5 (Jeris and Regan, 1973c; Willson, 1993). However, because of the natural buffering capacity of compost material, a much wider range of initial pH values can be tolerated (Willson, 1993). This allows a wide range of organic feedstocks to be composted whose pH can vary from a low of 5.0 to 6.5 for raw sludges (Haug, 1993) to highs of 11.0 for digested sludges treated with lime and ferric chloride (Shell and Boyd, 1969).

Temperature

Temperature is a key factor affecting biological activity within the composting process and is one factor that is maintained and controlled in any composting operation to ensure optimum growth and activity of the microorganisms. A wide range of microorganisms exist in a composting environment and each has its own optimum temperature for growth. Mesophiles prefer temperatures around 15 to 45°C, while thermophiles prefer temperatures between 45 to 70°C (Burford, 1994; Finstein, 1992; Golueke, 1989; Poincelet, 1977). Although temperature is viewed by most compost operators as a key operating parameter and is used by many to control the process and optimise the degradation, it is only part of the whole thermodynamics of the process (Finstein *et al*., 1986; Harper *et al*., 1992; Haug, 1993; McGregor *et al*., 1981; Naylor, 1996).

Some debate exists concerning optimum temperature conditions for composting. These differences of opinion seem to originate because of the different feedstocks used in the different studies (Epstein, 1997). A temperature of about 55°C seems to be most commonly aimed for (Polparsert, 1989) with operating temperature ranges between 35 to 60°C considered normal.

A7.4.3.3 Types of composting household biodegradable waste

Centralised composting

Centralised composting systems vary according to their level of complexity and degree of process control. In general, they are described as ‘open’ and ‘closed’ systems.

Open systems require continuous feeding and removal of organic matter and may be divided into two basic categories: turned windrows and aerated static piles (Figure A7.20). The windrow system is the least expensive and most common approach. The mixture of dewatered organic waste and bulking agent is stacked in rows called windrows and the composting mass is aerated by turning the windrows either manually or mechanically. Aerated static piles consist in the formation of piles of dewatered organic waste mixed with a bulking agent. The piles can be covered with screened compost to reduce odours and to maintain a high temperature inside the pile. Aeration is provided by means of blowers and air diffusers.

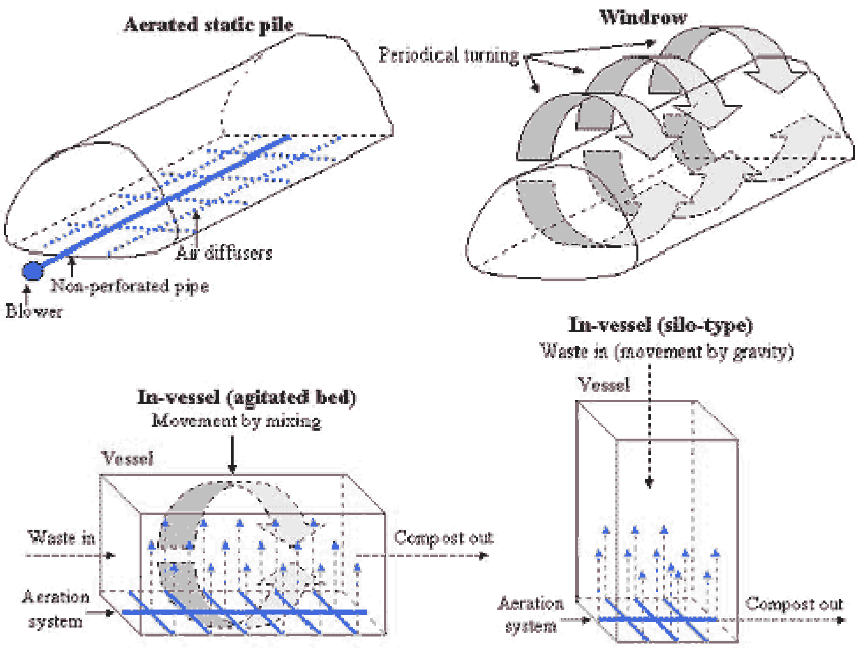


Figure A7.20 Types of centralised composting systems (Danish EPA, 2003)

On the other hand, closed systems are enclosed into containers (i.e. vessels) to ensure control of temperature, oxygen concentration and odours (Figure A7.19). Due to their high cost, enclosed systems are particularly appropriate when a high quality of the compost product is required. The vessel can be anything from a silo to a concrete-lined trench. The silo-type systems rely on gravity to move the composting material through the vessel, whereas in other enclosed systems (e.g. agitated bed system), the material is moved through the vessel by mixing, combining the advantages of windrow and aerated static pile systems.

About 5% of household waste was composted centrally in 2003/04 in England (DEFRA, 2005). In 2003/04, 45% of UAs and WDAs had established centralised composting schemes with 7% planning to introduce such a scheme. During the same financial year, 26 of the 32 Scottish local authorities used centralised composting schemes.

Home composting
Home composting is a simple, rewarding way to recycle garden and kitchen waste at home and creates a valuable soil amendment for gardens and lawns. It requires householders to separate and compost their own kitchen and garden waste in home compost bins or traditional composting heaps. The disadvantage of home composting is that it is limited to householders who have a requirement of compost and usually have an interest in gardening and it may not be feasible for premises with small or not gardens or apartment buildings.

By composting at home, the cost and environmental risks of managing solid waste materials is reduced. Kitchen and garden waste, such as leaves, grass clippings, garden debris, and small branches, make up over 27% of a typical household waste (Parfitt, 2002). When treated as waste, these materials increase the cost of collecting and handling MSW. In the landfill, they consume valuable space and create potential pollutants such as leachate and methane gas.

An estimated 73% of total authorities in England have distributed bins to households for home composting in 2003/04, and 9% did so free of charge (Table A7.24). These authorities distributed an estimated 257,000 home composting bins to add to the 1.8 million bins that local authorities had already distributed prior to 2003/04. In Wales, 192,667 compost bins were distributed to residents in 2004/05. The percentage of households that own at least one compost bin is 15.9% of total households in Wales, which equals to 1,213,000 households. In Scotland, 21 local authorities reported that they had distributed containers for home composting to the public during 2003/2004. A total of 24,121 composters and 1,231 digesters were distributed. Most of these were provided either free of charge or on a subsidised basis.

SEPA (1999) states that increased home composting has a role in achieving diversion of biodegradable household waste from landfill disposal, although anticipates that the overall may not be large. Moreover, Eunomia (2002) reports that the estimates of the extent of active engagement in home composing and the weight of biodegradable waste diverted through this option, are generally not reliable. In general, it is difficult to predict the extent of the potential impact of home composting on waste diversion rates due to voluntary nature of the activity and because it is linked with complete socio-economic and demographic features (Parfitt, 2002). A number of local authorities have attempted to quantify the weight of material diverted through home composting schemes but different survey methods made the collation of the results difficult (SEPA, 2005).

Table A7.24 Distribution of home composting bins prior to and in 2002/03 by authority type (DEFRA, 2005)

	prior to 2002/03	2001/02	2002/03	2003/04
No. distributed (composters and others)	1302	214	250	257
% of local authorities distributed free of charge	7%	7%	9%	9%
Total no. of local authorities distributing	231	229	235	235
% of all WCAs/UAs distributing bins within specified year	65%	65%	66%	73%

Note:
Adjustment for non-responding authorities.
'Composter' includes aerobic composting bins.

A7.5 Policy and regulations on household waste management

In the UK, the management of waste is controlled through a waste legislative and planning regime which was developed over decades (Williams, 2002). The regulatory system for waste management is covered by a number of Acts of Parliament and it is subject to continuing modification by legislation from European Union Directives.

A7.5.1 European Union Directives

European law on waste matters is contained in a range of Directives which set out various requirements for waste management practice in Member States and provide the framework within which many of the national rules on waste guidance are now set.

A7.5.1.1 The Landfill Directive

It is a substantial challenge for the UK to meet the targets set out by the European Landfill Directive (1999/31/EC) due to the extent of MSW disposal by landfilling. The Directive focuses on the harmonisation of controls on the landfill of waste throughout the European Union, and its main aims are to produce common standards for the design, operation, and aftercare of landfill sites and to reduce the amounts of CH_4 emitted from landfill sites. The UK has a wider legally binding target, agreed at Kyoto in December 1997, to cut emissions of greenhouse gases by 12.5% below 1990 levels by 2008-2012 (DEFRA, 1999).

The Directive sets three progressive targets for Member States to reduce the amount of biodegradable municipal waste sent to landfill:

- To reduce biodegradable municipal waste going to landfills to 75% of the total amount (by weight) of biodegradable municipal waste (BMW) produced in 1995 by 2006.
- To reduce biodegradable municipal waste going to landfills to 50% of the total amount (by weight) of BMW produced in 1995 by 2008.
- To reduce biodegradable municipal waste going to landfills to 35% of the total amount (by weight) of BMW produced in 1995 by 2016.

The Directive allows Member States which widely rely on landfill disposal, and in 1995 disposed of more than 80% of their collected municipal waste to landfill, to postpone the attainment of the targets by a period not exceeding four years. Accordingly, the UK is eligible and will adopt the extension revised to achieve compliance with the Directive.
In 1995, it was determined that 29 million t of MSW was produced and of that 60% was biodegradable (DETR, 1999b). As shown in Table A7.25, it is anticipated that the UK will be required to divert 30.3 million t of BMW from landfill by 2020 if the annual growth of MSW arisings is 3% and 12.9 million t of BMW if there is a 1% annual decrease in MSW arisings. The requirements of the Landfill Directive will be met by 2020 only if there is an annual reduction of 8.2% in BMW arisings.

This target is considered to be difficult to achieve due to a number of issues (Price, 2001):

- Current positive annual growth in waste arisings;
- Lack of market availability and stability for compost; and
- Inadequate funding and infrastructure for alternative treatment options.

A7.5.1.2 The Packaging and Packaging Waste Directive
Directive 94/62/EC on Packaging and Packaging Waste covers all packaging placed on the market in the Community and all packaging waste, whether it is used or released at industrial, commercial, office, shop, service, household or any other level, regardless of the material used. Directive 2004/12/EC (amending Directive 94/62/EC) establishes criteria clarifying the definition of the term "packaging".
Member States must introduce systems for the return and/or collection of used packaging to attain the following targets:

- no later than 30 June 2001 between 50 and 65 % by weight of packaging waste will be recovered or incinerated at waste incineration plants with energy recovery;
- no later than 31 December 2008 60 % as a minimum by weight of packaging waste will be recovered or incinerated at waste incineration plants with energy recovery;
- no later than 30 June 2001 between 25 and 45 % by weight of the totality of packaging materials contained in packaging waste will be recycled (with a minimum of 15 % by weight for each packaging material);
- no later than 31 December 2008 between 55 and 80 % by weight of packaging waste will be recycled;
- no later than 31 December 2008 the following recycling targets for materials contained in packaging waste must be attained: 60 % by weight for glass, 60 % by weight for paper and board, 50 % by weight for metals, 22.5 % by weight for plastics and 15 % by weight for wood.

Moreover, the Directive requires the implementation of national programmes for the prevention of packaging waste, and introduces the principle of producer responsibility which implies that the packaging industry must contribute to the costs of recycling and recovery.

Table A7.25 Diversion of BMW from landfill in the UK to meet Landfill Directive targets

	1995	2006 (2010)	2009 (2013)	2016 (2020)
With 3% annual waste growth				
Total BMW[a] ($x10^6$ t y^{-1})	17.4	24.1 (27.1)	26.3 (29.6)	30.3 (36.4)
BMW allowed to landfill ($x10^6$ t y^{-1})	No target	13.1	8.7	6.1
BMW to be diverted ($x10^6$ t y^{-1})	No target	11.0 (14.0)	17.6 (20.9)	26.2 (30.3)
With 1% annual waste reduction[b]				
Total BMW[a] ($x10^6$ t y^{-1})	17.4	21.9 (21.0)	21.2 (20.4)	19.8 (19.0)
BMW allowed to landfill ($x10^6$ t y^{-1})	No target	13.1	8.7	6.1
BMW to be diverted ($x10^6$ t y^{-1})	No target	8.8 (7.9)	12.5 (11.7)	13.7 (12.9)
With 8.2% annual waste reduction[c]				
Total BMW[a] ($x10^6$ t y^{-1})	17.4	20.3 (14.4)	15.7 (11.1)	8.6 (6.1)
BMW allowed to landfill ($x10^6$ t y^{-1})	No target	13.1	8.7	6.1
BMW to be diverted ($x10^6$ t y^{-1})	No target	7.2 (1.3)	7.0 (2.4)	2.5 (0.0)

Notes:
[a] Based on 1995 municipal waste arisings to be $29x10^6$t $y^{-1}$and biodegradable MSW representing 60% of that figure.
[b] For municipal waste arisings in 2005, an increase of 2% was applied based on the provisional MSW arisings for England. For municipal waste arisings from 2006 onwards, an annual waste reduction of 1% was applied.
[c] For municipal waste arisings in 2005, an increase of 2% was applied based on the provisional MSW arisings for England. For municipal waste arisings from 2006 onwards, an annual waste reduction of 8.2% was applied.

A7.5.1.3 Other European Directives

The Waste Framework Directive (75/442/EEC) **-** The Directive requires Member States to prohibit the uncontrolled discarding, discharge and disposal of waste and to promote the prevention, recycling and conversion of wastes with a view to their re-use. Introduced the ‘waste hierarchy’ principle.

The Integrated Pollution, Prevention and Control (IPPC) Directive (96/61/EC) - The purpose of this Directive is to achieve integrated prevention and control of pollution arising from industrial activities listed in its Annex I. It lays down measures designed to prevent or, where that is not practicable, to reduce emissions to the air, water and land from the listed industrial activities, including measures concerning waste, to achieve a high level of protection of the environment taken as a whole.

Directive on Waste Incineration (2000/76/EC) - This Directive aims to prevent or reduce, as far as possible, air, water and soil pollution caused by the incineration or co-incineration of waste, as well as the resulting risk to human health. When the proposal for this Directive was introduced the Community's waste incineration system was covered by Directives 89/369/EEC, 89/429/EEC (new and existing municipal waste-incineration plants) and 94/67/EC (incineration of hazardous waste). This Directive intended to fill in the gaps existing in that legislation. Apart from the incineration of non-toxic municipal waste its scope extends to the incineration of non-toxic non-municipal waste, such as sewage sludge, tyres and hospital waste, and toxic wastes not covered by Directive 94/67/EC, such as waste oils and solvents.

A7.5.2 UK Legislation and policies

A7.5.2.1 The Environment Protection Act 1990

The Environment Protection Act 1990 set out the waste management strategy of the UK and introduced the system of Integrated Pollution Control. Part I of the Act deals with prescribed processes, including waste incineration, and Part II deals with disposal of waste on land, including landfill. The innovative concept of Integrated Pollution Control was based on viewing the environmental impacts on the air, water and land as a whole. Its main emphasis is the control of waste at the point of production rather at the point of disposal along with the strategies to minimise pollution to the air, water and land.

A7.5.2.2 The Environment Protection Act 1995
The Environment Protection Act 1995 established the Environment Agency to further the aims of integrated pollution control introduced in the 1990 Environment Protection Act. The Agency, which came into operation in April 1996, takes over the responsibilities of the Waste Regulation Authorities for the licensing for all waste disposal, storage, transfer, and treatment plants and landfill sites.

A7.5.2.3 Landfill Allowance Trading Scheme (LATS)
To enable England to meet its targets, as a contribution to the UK targets, under the Landfill Directive, the Landfill Allowance Trading Scheme (LATS) was launched on 1st April 2005 (DEFRA, 2003d). The Waste and Emissions Trading Act (2003) provides the legal framework for the scheme and for the allocation of tradable landfill allowances to each waste disposal authority in England. These allowances convey the right for a waste disposal authority to landfill a certain amount of biodegradable municipal waste in a specified scheme year.
Each waste disposal authority is able to determine how to use its allocation of allowances in the most effective way. It is able to trade allowances with other authorities; save them for future years (bank) or use some of its future allowances in advance (borrow). This allows individual waste disposal authorities to use their allowances in accordance with their investment strategy. A fixed penalty of £150/t incurs if a WDA breaches its landfill allowances target in the scheme year.

A7.5.2.4 Waste Minimisation Act 1998
The Waste Minimisation Act, which became law in November 1998, allows a local authority to "do or arrange for the doing of, anything which in its opinion is necessary or expedient for the purpose of minimising the quantities of controlled waste, or controlled waste of any description, generated in its area". The intention behind the Act was to clear up any legislative uncertainty about whether councils could actually carry out initiatives to reduce the amount of waste (as opposed to recycle it). The Act does not place any obligation on authorities to carry out such initiatives, nor does it allow councils to impose any requirements on businesses or householders in their area.

A7.5.2.5 Waste Strategy 2000
In May 2000 the Government and the National Assembly published a White Paper named ‘The Waste Strategy 2000 for England and Wales’ which set out a number of key waste management principles which should underpin all waste management decisions (Strategy Unit, 2002). It adopted the waste hierarchy and Best Practicable Environmental Option (BPEO), introduced in a previous section of this report, and set a number of targets to assist in achieving the goal of sustainable waste management. The targets for the recovery of

municipal and household waste are anticipated to be met through increased recycling, composting and energy recovery and have been established to assist in compliance with the requirements of the Landfill Directive.
Municipal Waste Targets:

- To recover value from 40% of municipal waste by 2005;
- To recover value from 45% of municipal waste by 2010;
- To recover value from 67% of municipal waste by 2015.

Household Waste Targets:

- To double the recycling rate by 2003;
- To recycle or compost at least 25% of household waste by 2005;
- To recycle or compost at least 30% of household waste by 2010;
- To recycle or compost at least 33% of household waste by 2015.

Under the Best Value initiative, which is a Government initiative to improve the quality of local authority services to be achieved through consultation with key stakeholders and by increased emphasis on quality rather than cost, local authorities in England and Wales must set a series of targets for performance on waste management, and prepare an action plan for their delivery. In setting many of these targets authorities must have regard to the waste strategy, and in particular to the targets indicated above. To ensure that the targets are met, the Government will introduce statutory performance standards for recycling by local authorities in England. The Best Value Indicators for local authorities on waste management include data regarding:

1. Total tonnage of household waste arisings:
   – percentage recycled;
   – percentage composted;
   – percentage used to recover heat, power and other energy sources;
   – percentage landfilled.
2. Weight of household waste collected per person;
3. Cost per kilometre of keeping land for which the local authority is responsible to clear of litter and refuse;
4. Cost of waste collection per household;
5. Cost of waste disposal per t for municipal waste;
6. Number of collections missed per 100,000 collections of household waste;
7. Percentage of people satisfied with cleanliness standards;
8. Percentage of people expressing satisfaction with: (a) recycling facilities, (b) household waste collection and (c) civic amenity sites; and
9. Percentage of population served by kerbside collection of recyclables, or within one kilometre of a recycling centre.

The Waste Strategy 2000 also indicates the desirability of recovering or disposing of waste close to the place where it is produced in order to limit economic and environmental costs. This is referred to as the “Proximity Principle”. There are four principal reasons for promoting it:

a. it should encourage waste producers, including the community at large, to take more responsibility for their waste;
b. it is more likely to accord with the principles of sustainable development by reducing distances over which materials have to be transported;
c. it may assist the local economy;
d. overall costs should be lower.

The degree of relative proximity will however depend on the precise nature and location of the activity and the sources, nature and location of waste arisings, and consequently necessitates a level of flexibility in interpretation.