A Study of the Composition of Collected Household Waste in the United Kingdom - with Particular Reference to Packaging Waste

R&D Technical Report P347

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Statement of use
The information within this document is for use by Environment Agency staff and others involved in waste management and in particular waste planning. The report provides estimates of the main constituents of household waste from selected households in different local authorities across the UK. Data on the packaging content of the waste is also provided.

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EXECUTIVE SUMMARY

Waste from selected street blocks of 50 households from 20 different local authorities across the United Kingdom was sampled for compositional analysis in conjunction with a postal questionnaire designed to elicit information on household characteristics and behaviour. The main objective was to produce national estimates of the main constituents of collection round (dustbin) waste, with particular emphasis on the packaging content. The research design was based on the need to understand sources of variation in packaging and non-packaging wastes in terms of household characteristics generated by the questionnaire survey.

Waste samples were hand sorted into 7 main (primary) categories and waste from one-in five households was further sub-divided into 38 (secondary) categories. The Agency data were augmented by data collected to a similar format from a study of household waste minimisation commissioned by 'Going for Green'. The combined sample included linked questionnaire and compositional data from 800 households at the primary level and 250 at the secondary level.

Overall it was estimated that packaging waste contributed about 20% of the weight of collection round household waste, equivalent to 3.7 million tonnes per year for the United Kingdom (1997/98). In addition, it was estimated that 450,000 tonnes of packaging waste from household sources was being recycled: a recycling rate of about 11% of the total packaging content of the collection round waste stream.

Seasonality in the ratio of packaging to non-packaging wastes was identified as a source of uncertainty in the estimates. The waste samples were mainly taken in April and May, when larger quantities of garden waste were likely to have arisen. A comparison with selected National Household Waste Analysis Project data for different seasons and methods of waste containment concluded that 20% packaging waste was likely to be an under estimate. The 'best-guess' UK estimate, taking into account an element of seasonality was 4.5 million tonnes of packaging waste, including the recycling element.

Total packaging waste was found to be positively correlated with a number of household factors of which household size (number of occupants) had the largest correlation coefficient. A number of household variables from the questionnaire survey were found to directly influence specific packaging components (e.g. pet ownership and metal cans, frequency of cooking pre-packed foods and plastic packaging, frequency of recycling and reduced quantities of glass/metal packaging). However, many of these factors were found to be inter-correlated with one another (e.g. method of waste containment and household size), which made interpretation of the main influences on the weight of packaging waste discarded more problematic.

Overall the research demonstrates a method of linking household characteristics to data on waste composition as well as providing a means of producing national estimates for the main components of the collection round waste stream. Research to a similar design in the future should include provision for measuring seasonality of waste composition and all waste samples should be sorted to the secondary level.

KEYWORDS

Waste, packaging, refuse, recycling, EC Packaging Directive.

1. INTRODUCTION AND OBJECTIVES

The EC Packaging Directive (94/62/EC) places obligations on European Member states to achieve specified targets for recovery and recycling of packaging waste by the year 2001. Implementation in the UK has been through regulations under section 93 of the Environment Act 1995: the Producer Responsibility Obligations (Packaging Waste) Regulations 1997. The 1997 Regulations set a national target to recover 52% and to recycle 26% of packaging by 2001, with a minimum of 16% recycling rate for each of the main materials: glass, metal, paper/board and plastic.

The Environment Agency is responsible for submitting compliance data to the European Union on behalf of the UK Government. In order to do so, the Agency has a requirement to improve the quality of statistics currently available which describe the composition of wastes streams into which packaging and packaging wastes are discarded. Consequently, the Environment Agency retained a consortium led by the University of East Anglia to undertake a project that sought to assess the weight of packaging discarded in collected (dustbin) household waste.

Specific objectives were to:

- gather detailed information on the composition and weight of packaging waste in collected household waste
- gather compositional and weight data on non-packaging components
- to examine the results and compare and contrast with the household waste compositional studies reviewed on behalf of the Environment Agency, including the National Household Waste Analysis Programme
- produce a report for publication by the Environment Agency detailing and discussing the findings of the project.

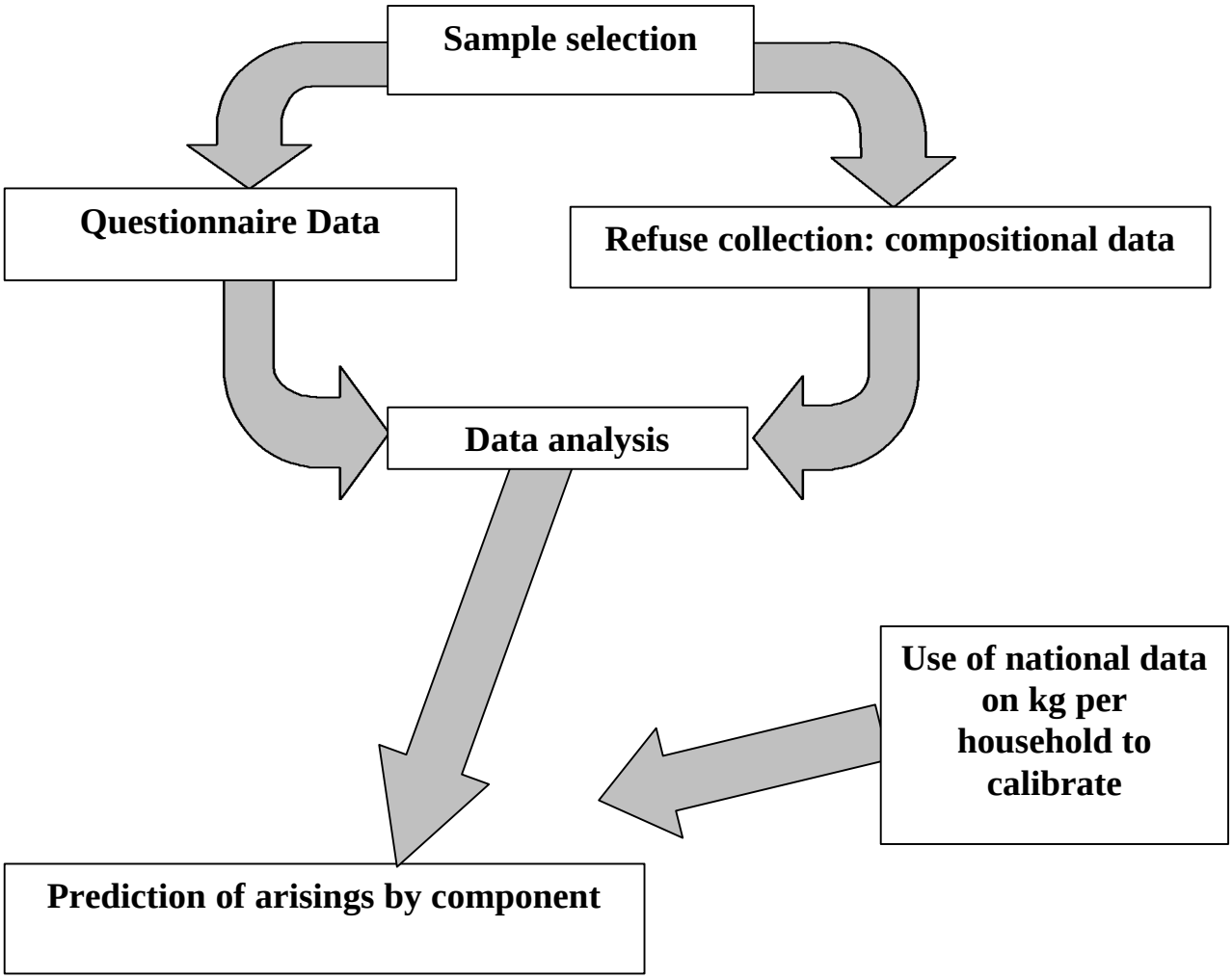
2. METHODOLOGY

2.1 Introduction

Research focused on the collection of waste composition and behavioural data from individual households within sampled street blocks, rather than using bulked waste samples from selected areas. An overview of the research design is shown in **Figure 2.1**.

The household-based approach was adopted in order that weight data on packaging and non-packaging wastes could be directly linked to individual household characteristics and to the socio-economic, spatial and temporal variables that influence waste quantity and composition.

Figure 2.1: Research design



Although the National Household Waste Analysis Project (NHWAP 1994) had provided basic compositional data in sufficient detail on the main packaging categories, it was not possible to relate these data directly to household characteristics (despite the considerable investment by the Department of the Environment) other than at the aggregated level of the

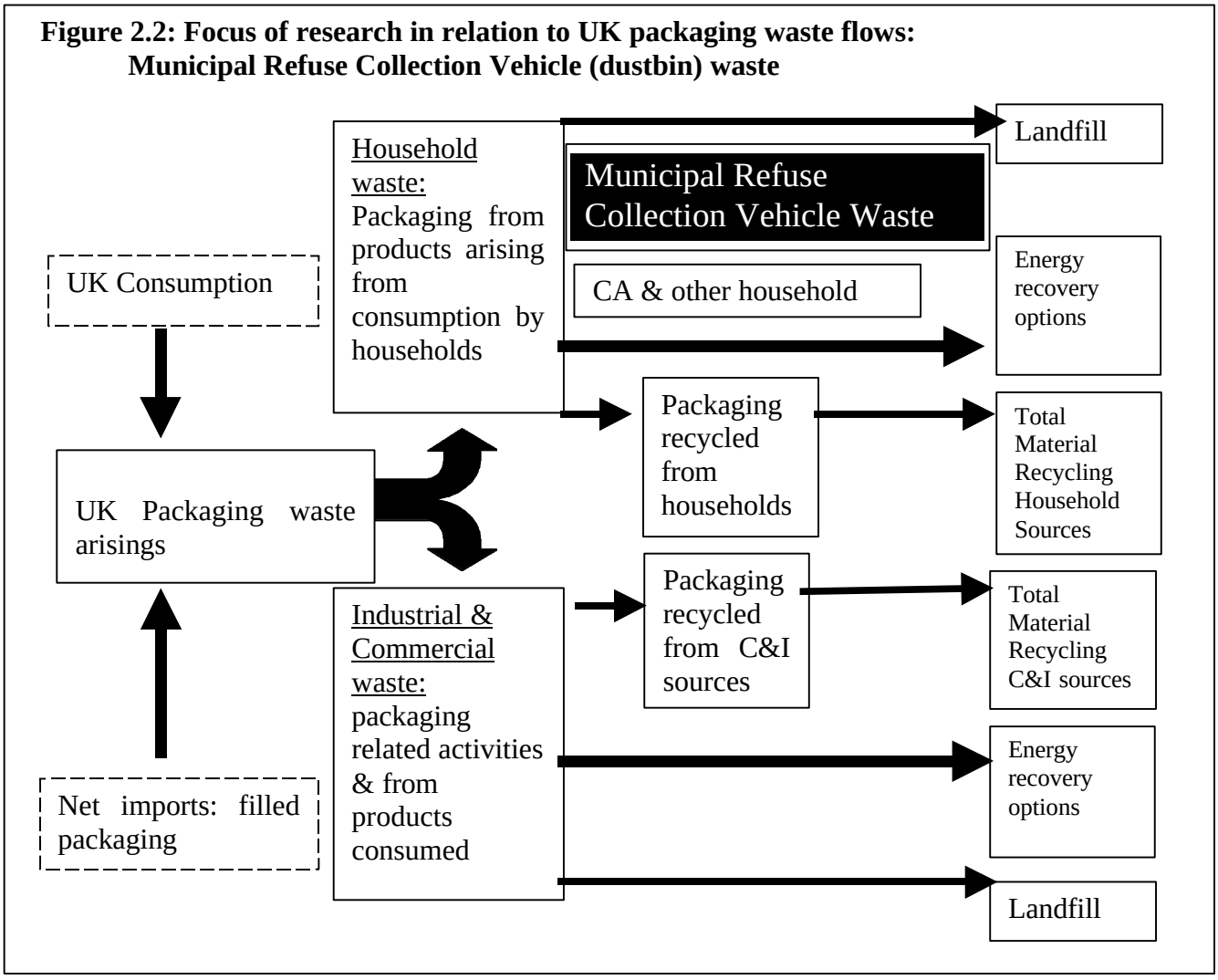
Enumeration District (E.D.) for the selected neighbourhoods. Furthermore, the number of samples taken was small (31 bulked samples from 12 local authorities). These factors limited the possibilities of using the data for predicting national quantities of packaging waste in collection round household waste (Parfitt and Flowerdew 1997).

2.2 The research problem: different outlets for packaging waste

Packaging waste appearing in the household waste stream and discarded as dustbin waste is only one component of the flow of packaging waste through the UK economy (**Figure 2.2**). It is important to consider how this compositional study fits into the wider context of these packaging flows.

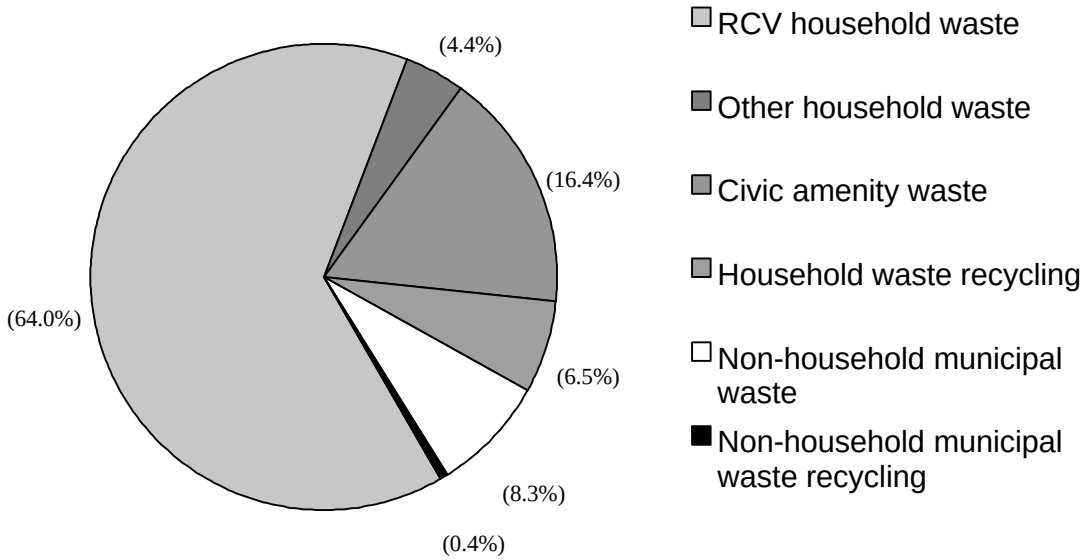
Apart from household sources of packaging waste, significant quantities are generated from different packaging –related activities in the industrial and commercial sectors. The relative importance of household to industrial and commercial sources will vary with packaging type. For instance, plastic bottles are likely to be found almost exclusively in the household waste stream, whereas paper packaging, such as cardboard casings used in transit packaging, is likely to be predominantly from non-household sources.

Figure 2.2: Focus of research in relation to UK packaging waste flows: Municipal Refuse Collection Vehicle (dustbin) waste



For packaging wastes in the household waste stream the main disposal route is through the regular refuse vehicle collection rounds (**Figure 2.3**). However, particular types of packaging may appear disproportionately in other outlets (civic amenity sites, privately hired skips, and street litter collections). Bulkier items of packaging, such as cardboard packaging from white goods, are more likely to be disposed of by householders at civic amenity sites (or taken there for recycling). Furthermore, differences in capacity of the different methods of waste containment used for setting out waste for the refuse collection vehicle will be an important factor in a householder's decision making. Districts with wheeled bin collections are likely to receive less civic amenity waste from household sources than those in which households are provided with plastic sacks as a method of waste containment. The greater bin capacity and the rigidity of the 240 litre wheeled bin container permits households to dispose of bulkier items than households with plastic sack collection or smaller wheeled bins. The method of waste containment will therefore influence quantity and composition of packaging waste in the 'dustbin': this factor was considered important in area selection for this study.

Figure 2.3: Estimated proportion of municipal waste collected by different outlets
England and Wales, 1996/97 {DETR/WO: in press}



2.3 Packaging waste and materials collected for recycling from household sources

Further complexity to the task of estimating household packaging waste can be attributed to district-to-district (and house-to-house) variations in materials collected from household sources for recycling. Apart from newspapers and magazines, 'dry recyclables' collected from households are dominated by packaging materials (the main elements being glass bottles/jars, plastic bottles, metal cans and cardboard). The extent of packaging waste recycling by households partly reflects differences in convenience in use of recycling

schemes as well as socio-economic factors that influence householder motivation and participation (M.E.L Research Ltd. 1994).

Ideally all materials destined for recycling activity should be included in a study of packaging waste, however, it is difficult to design a household-based study that includes direct measurement of 'bring' site recycling. Originally it was intended to use data from household questionnaires to estimate likely bring site quantities per household. This approach depended on a high response rate to the questionnaire survey in order that factors derived from it could be applied to the majority of the compositional data. The capture of kerbside recyclables is in principle more straight forward, however, the significant expansion of kerbside collection schemes in England and Wales has occurred since the fieldwork for his study was undertaken (mainly between 1996/97 and 1997/98). Kerbside collection is therefore not well represented in the data set.

An alternative to measurement of household packaging waste collected for recycling alongside the refuse analysis is to use national recycling data and to estimate the overall packaging content within it. Information on quantities of different materials collected for recycling is available from a number of sources (DETR/National Assembly for Wales, materials organisations, and packaging regulation compliance schemes). There are three main problems in using these data sources for the estimation of current recycling of packaging from household sources:

1. lack of comprehensive coverage (geographically or sectorally: local authority v private/voluntary schemes)
2. difficulties in distinguishing between commercial/industrial sources and household sources
3. inability to distinguish material type and packaging v non-packaging in mixed material categories (e.g. 'mixed paper/card', 'mixed cans', 'co-mingled kerbside

Despite these uncertainties, this approach was adopted as likely to be more reliable than estimates derived from the household questionnaire survey and compositional analysis.

The main methodological tasks are summarised in **Table 2.1**, these are described briefly in Sections 2.4-2.7 and full details are contained within the **Technical Annexes** at the end of the report.

2.4 Area sampling & street block selection

While there is likely to be major variation between households of similar characteristics with regard to packaging waste, the much greater sample size that is possible using the household-based approach can establish the range of behaviour for households sampled as well as the mean. If the areas for sampling households (EDs, or street blocks within EDs) are chosen because they represent a wide range of values for Census variables relevant to packaging wastes, results can be used more effectively to estimate national packaging waste. The sampling strategy adopted for the current research was based on variables identified through earlier research for the National Household Waste Analysis Project (Flowerdew, R. and Parfitt, J. P. 1994). **Annex A1** contains details of the sampling method used in the selection of the 20 primary EDs from which street block samples of 50 households were taken.

Fieldwork was conducted in April and May 1996 by M.E.L Research and the University of Luton, with the exception of the Northern Ireland sample, which was taken in February 1997 by Aspinwall & Co. Ltd.

Table 2.2 provides a summary sample area location, method of waste containment provided to householders and which team of sub-contractors undertook the waste collection and sorting. Eleven of the twenty street-block samples were on wheeled-bin collection. Two of the sampled areas were served by kerbside collection of recyclables.

Table 2.1: Summary of main methodological tasks detailed in Annexes A1-A4

Area Sampling & Street Block Selection **Annex A1**	♦ Local Authority selection ♦ Enumeration District Selection within Local Authorities ♦ Logistic considerations in Local Authority & street block selection
Household waste sample collection **Annex A2**	♦ Local Authority liaison ♦ Method of intercepting collection round waste ♦ Type of vehicle ♦ Gauge of sacks ♦ Staff recruitment ♦ Procedures for collecting plastic sack and wheeled bin wastes
Hand-sort methodology Packaging-sort protocols & procedures **Annex A3**	♦ Primary and secondary levels of packaging & non-packaging categorisation ♦ Inclusions and exclusions from packaging definitions ♦ Site procedures
Household questionnaire & report on survey administration **Annex A4**	Collection of household variables relevant to waste composition, recycling and overall quantities arising and consignment to various outlets

Table 2.2: Collection schedule showing areas visited, method of waste containment and details of which sub-contractors made pick-up

Local Authority	Ward	Date	Mode	Details of kerbside	Collected by
1. Antrim	Masserene	Feb 97	Wheeled Bins		Aspinwall & Co. Ltd.
2. Daventry	Weedon	22.4.96	Wheeled Bins	Kerbside recyclables mixed with refuse	M.E.L Research
3. Bolsover	Pinkston	23.4.96	Wheeled Bins		M.E.L Research
4. South Derbyshire	Gresley	24.4.96	Wheeled Bins		University of Luton
5. Redcar andCleveland	Brotton	24.4.96	Wheeled Bins		M.E.L Research
6. Wychavon	Drakes Broughton	25.4.96	Sacks		University of Luton
7. Kingston-upon-Hull	Newington	25.4.96	Wheeled Bins		M.E.L Research
8. Ealing	Dormers Wells	26.4.96	Sacks		M.E.L Research
9. Canterbury	Barton	26.4.96	Wheeled Bins	Fortnightly kerbside scheme, refuse sample excluded kerbside materials, collected during non-kerbside week	University of Luton
10. Sheffield	Stocksbridge	29.4.96	Wheeled Bins		M.E.L Research
11. Southampton	Sholing	29.4.96	Wheeled Bins		University of Luton
12. Carrick	Mylor	30.4.96	Sacks		University of Luton
13. Blyth Valley	Hartford East	30.4.96	Wheeled Bins		M.E.L Research
14. Lincoln	Tritton	30.4.96	Sacks and Palladins		University of Luton
15. Coventry	Brownshill Green	1.5.96	Wheeled Bins		M.E.L Research
16. Waveney	Whitton	1.5.96	Wheeled Bins		University of Luton
17. Westminster	Hamilton Terrace	2.5.96	Sacks and Palladins		University of Luton
18. Aberdeenshire	Gordon	2.5.96	Sacks		M.E.L Research
19. Newbury	Compton	3.5.96	Wheeled Bins		University of Luton
20. Swansea	Pen Slawdd	3.5.96	Sacks		University of Luton

2.5 Household waste sample collection

Household waste was intercepted on collection round days before the refuse collection vehicles had collected from the households within selected street blocks. Each household's waste was labelled so that results of compositional analysis could be linked with questionnaire data obtained from each household. In the case of street blocks with wheeled bins, waste was carefully decanted into large plastic sacks for analysis at the depot. In street blocks with plastic sack collection, extra care was necessary in recording which sacks belonged to which households, as there was greater potential for sacks from neighbouring properties to become switched or displaced during the collection process. No practical measures could be taken to prevent householders positioning their plastic sacks at ambiguous points on the kerbside. **Annex 2** contains further details of the waste sample collection methods used.

2.6 Hand-sort methodology

The basic hand-sort methodology was similar to that used in other studies (Rufford 1984, M.E.L 1994) and the same as that used by M.E.L Research in a study commissioned by 'Going for Green' in 1997. Data from the latter were combined with data collected for this study, for reasons discussed later. Details of equipment and procedures used are provided in **Annex A3.**

The categorisation developed with the Agency specifically for this study contained two levels of that were applied in the hand-sorting operation (**Table 2.3**). All waste was sorted into seven (primary) categories and one-in five of the sampled households were further divided into 38 (secondary) categories.

2.7 Household questionnaire

A postal questionnaire was used to elicit household variables relevant to waste composition, recycling and overall quantities arising and consignment to various outlets (collection rounds, civic amenity sites, recycling and in-situ options: bonfire, re-use, home composting). **Annex A4** contains a résumé of the questionnaire design and a copy of the questionnaire.

The postal questionnaire was sent out in July 1997, with a follow-up reminder letter in late August 1997.

Table 2.3: Primary and secondary levels of waste categories

PRIMARY CATEGORIES	SECONDARY CATEGORIES
1. Paper & card packaging	1. Paper packaging
	2. Corrugated card
	3. Non-corrugated card (non-grey)
	4. Non-corrugated card (grey)
	5. Other paper and card packaging
2. Plastic film packaging	6. Film wrapping
	7. Metalised film
	8. Other plastic film packaging
3. Dense plastic packaging	9. Bottles
	10. Expanded brown plastic
	11. Other dense plastic packaging
4. Glass packaging	12. Clear containers
	13. Brown containers
	14. Green containers
	15. Other glass packaging
5. Metal packaging	16. Ferrous beverage cans
	17. Ferrous food cans
	18. Ferrous aerosol cans
	19. Ferrous closures
	20. Other ferrous packaging
	21. Non-ferrous beverage cans
	22. Non-ferrous food cans
	23. Foil containers
	24. Non-ferrous closures
	25. Other non-ferrous packaging
6. Wood and miscellaneous packaging	26. Wood packaging
	27. Miscellaneous packaging
7. Non-packaging waste	28. Paper and card non-packaging
	29. Glass non-packaging
	30. Plastic film non-packaging
	31. Dense plastic non-packaging
	32. Textiles non-packaging
	33. Ferrous metal non-packaging
	34. Non-ferrous metal non-packaging
	35. Putrescibles
	36. Miscellaneous combustibles
	37. Miscellaneous non-combustibles
	38. < 10 mm fines

3. COMPLETED SAMPLE: WASTE COMPOSITION AND QUESTIONNAIRE DATA

3.1 The Environment Agency sample

The final data set for estimation of packaging waste required the linking of household waste compositional data to individual household questionnaires. Although some meaningful analysis was possible without questionnaire data (e.g. waste composition analysed by method of waste containment) the research design depended on using information from the household questionnaires to explore variations in waste composition.

Overall, 45% of the waste samples did not have linked questionnaire data, either because no questionnaire was returned (40% of cases) or due to new occupants moving to a sampled address during the time-lag between waste analysis and dispatching of postal questionnaires (5% of cases). In three cases questionnaires were returned from addresses that were not part of the waste sampling exercise.

Table 3.1: Outcome of questionnaire survey and primary compositional analysis

	Frequency	Percent
• questionnaire: no waste data	3	< 1%
• waste data: no questionnaire	418	40%
• new occupants since waste analysis	55	5%
• completed questionnaire & linked waste analysis	572	55%
Total	**1,048**	**100%**

Figure 3.1 shows variation in questionnaire response rates across the 20 areas sampled. In 15 areas the response rate was 55% or higher. However, in two cases response rates of 9% and 23% were recorded, below the rate usually expected for postal surveys of this type. The reason for this poor response was that in the case of Carrick and Waveney the address labels generated by the sub-contractors lacked full postal details and most were therefore 'returned to sender' by the Post Office. It is estimated that this administrative error accounted for a loss of approximately 45 responses (assuming 60% response rate) or about 4% of the total sample. More importantly, these two areas were not well represented in the questionnaire data, significantly reducing the overall coverage of the analysis. The sample of secondary compositional data was equally reduced by the response rate problem. The final sample available with linked questionnaire data was reduced from 252 households to 128 (**Figure 3.2**) as many of the household samples that had been sorted at the secondary level did not respond to the postal questionnaire.

Figure 3.1: Percent of households returning postal questionnaires by area Environment Agency sample: 1,048 households, April/May 1996, Feb. 1997

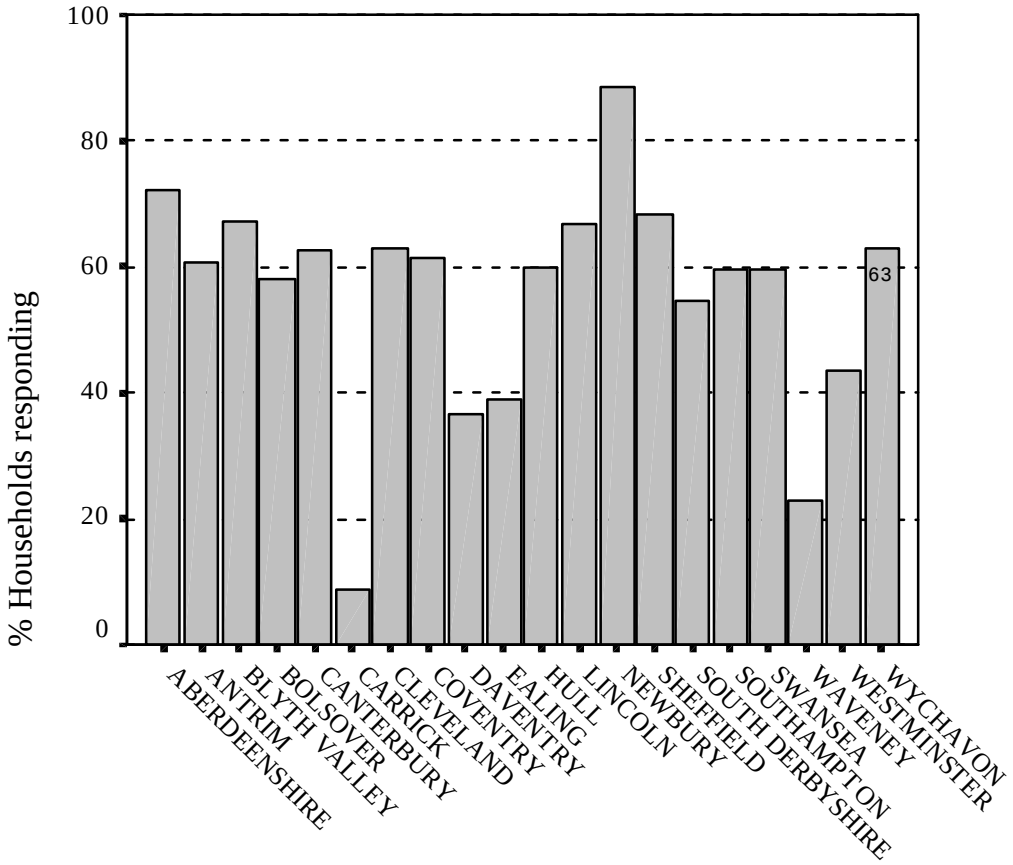
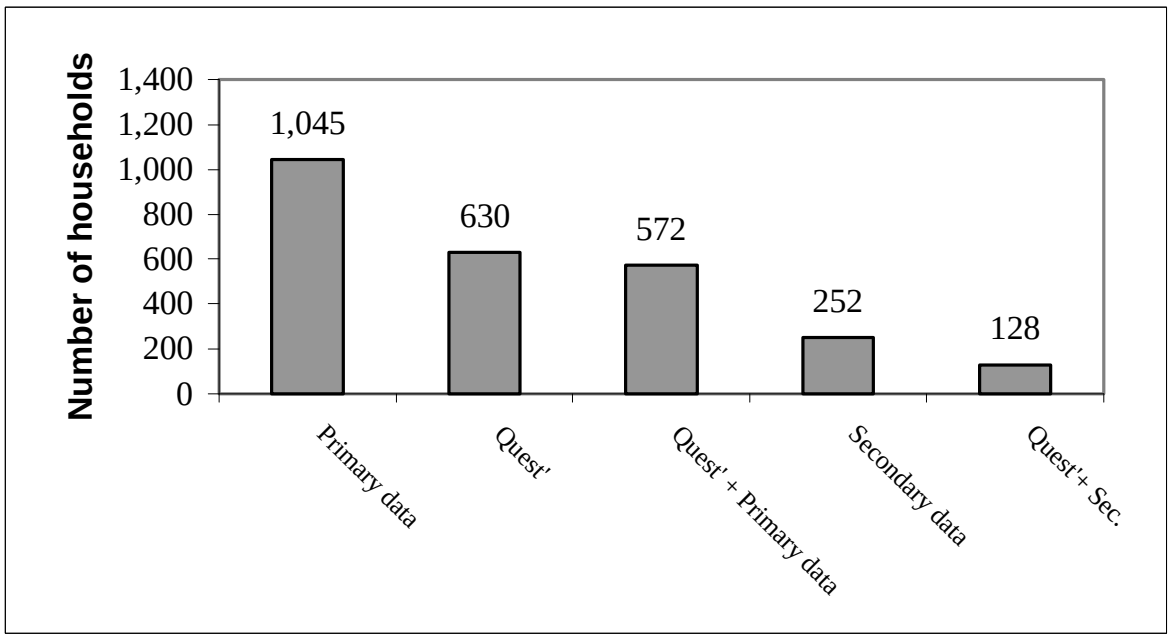


Figure 3.2: Environment Agency sample 1996/97: completed waste analysis & questionnaire responses



3.2 Supplementary data from the 'Going for Green' household waste minimisation study 1997

In 1997 a similar data set to that generated by the current study was collected as part of a national research project designed to examine the potential for household waste minimisation. The research was commissioned by 'Going for Green' (a government-funded national environmental campaigns group) and involved street block samples in four different locations (**Table 3.2**). Waste from selected households was sorted at three different points of the year, pre- and post- the minimisation campaigns. Areas were chosen to reflect differences in methods of waste containment and socio-economic conditions. Questionnaire formats and waste sorting protocols were compatible with the Agency study.

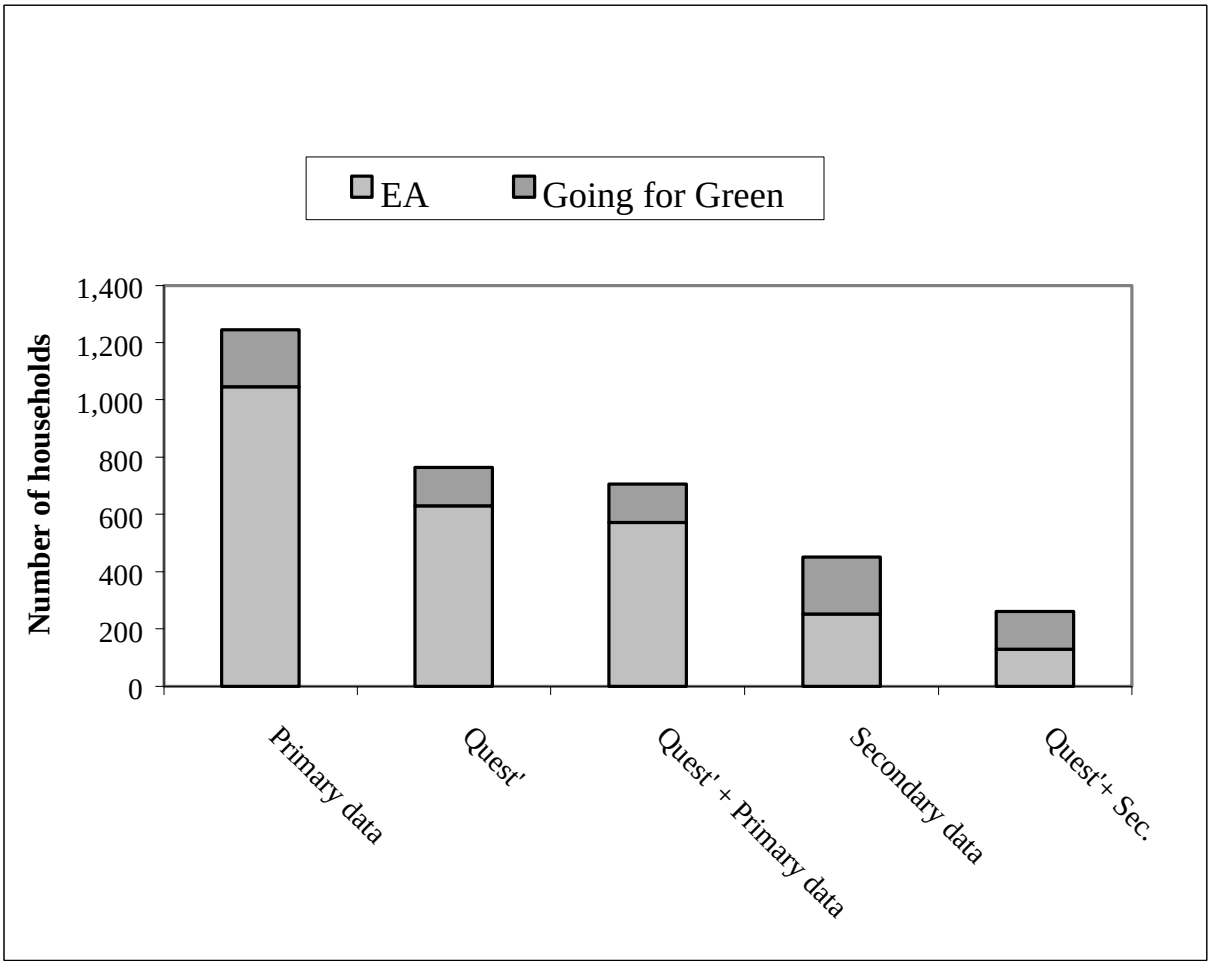
Table 3.2: details of the 'Going for Green' street block samples

Area	Location	Fieldwork	Recyclable collection	Refuse containment
Nailsea	South West/ suburban	May 1997	Kerbside, multi-material analysed separately	Householder provides sacks/dustbins
Kirklees	Northern/ suburban	May 1997	Bring scheme	Sacks
Dereham	Eastern/rural	May 1997	Kerbside, paper only; analysed separately	Wheeled bins
Harrow	South East/ urban	May 1997	Kerbside, paper only; Analysed separately	Wheeled bins

Permission was obtained from 'Going for Green' to include their pre-campaign data in the current study with the objective of improving the data coverage and sample sizes: particularly for the secondary data set. Although the 'Going for Green' research involved fewer households than the current study, all contributed to the secondary waste sort and questionnaire responses were generally higher.

Figure 3.3 shows the combined sample available as a result of the addition of the 'Going for Green' data. The most significant contribution was the increase from 252 to 452 households in the secondary data set. Although the 'Going for Green' households dominated the combined secondary sample, this was considered to be less of a problem than attempting to represent details of national packaging waste composition based on a sample size of only 252. Sections 4-6 of the main report are based on the combined sample, whereas the report on the questionnaire survey in section 7 is based on Environment Agency questionnaires only.

Figure 3.3: Combined Agency 1996/97 & 'Going for Green' 1997 samples



4. RESULTS: COMBINED ENVIRONMENT AGENCY AND 'GOING FOR GREEN' SAMPLE

4.1 Introduction

The main results from the analysis of the combined sample have been divided into four inter-related sections with the ultimate goal of producing and qualifying national estimates for both the packaging and non-packaging elements of 'dustbin' waste:

1 Variations in total packaging and non-packaging waste
2 Variations in primary compositional components
3 Results from secondary level sort and national estimates of packaging & non-packaging components
4 Comparisons with results from National Household Waste Analysis Project 1992/93

4.2 Variations in total packaging and non-packaging waste

The first analytic task was to use primary level sort data to explore variations in the total weight of packaging and non-packaging waste produced by households. It was decided to exclude Daventry from this exercise as kerbside collection had been included in the total refuse sort, but quantities of recyclables had not been recorded separately during the sorting operation. Ideally, data with and without kerbside weight data should have been collected: as was the case with the 'Going for Green' data. The exclusion of the Daventry left 1,211 cases in the main analysis.

Overall a mean value of about 3-kg of packaging waste per household per week was obtained and nearly 13 kg for non-packaging waste. However, differences were found between mean values when wheeled bin and non-wheeled bin samples were compared for total packaging and non-packaging waste, with wheeled bin households producing greater quantities of both. As the histograms in **Figures 4.1-4.4** reveal highly skewed (non-normal) distributions, non-parametric statistical tests were applied to the comparisons. Mann-Whitney U tests established that the differences in median quantities discarded by wheeled bin and non-wheeled bin households were statistically significant, but more so in the case of non-packaging waste (Z value –7.8, p=0.000) than with packaging waste (Z value –3.4, p=0.000). A full explanation of the Mann-Whitney U test can be found in any introductory textbook (see Wonnacott and Wonnacott 1990). The greater capacity for 240 litre wheeled bins to contain bulky non-packaging items, such as newspaper and garden waste, accounted for this difference. The maximum weight recorded for non-packaging waste from a wheeled bin household was over 85 kg, with 5% of households discarding more than 35 kg. Households not served by wheeled bin collection were less likely to discard similar quantities of non-packaging waste, with 2% discarding more than 35 kg to a maximum recorded value of 60 kg.

Figure 4.1: Histogram of total weight of packaging waste produced by non-wheeled bin households

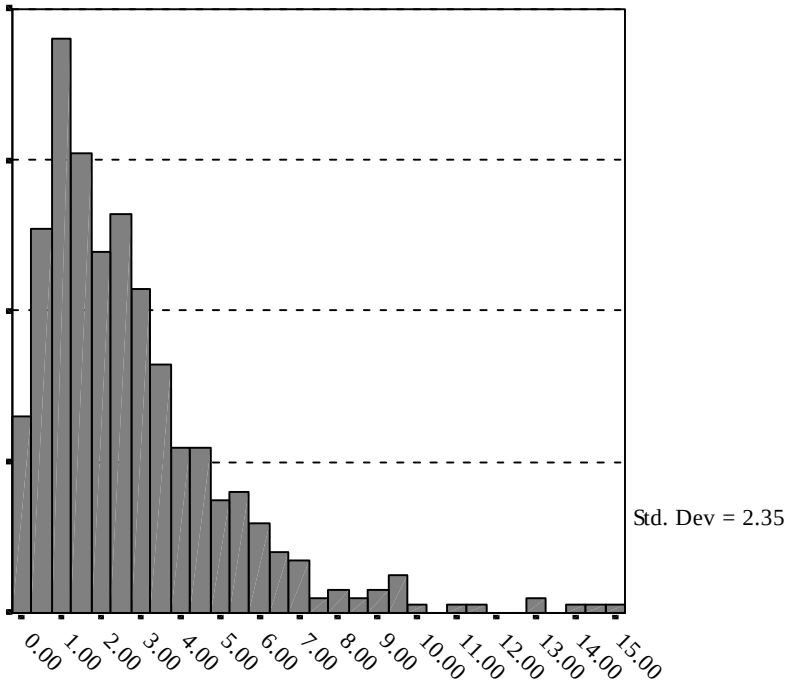


Figure 4.2: Histogram of total weight of packaging waste produced by wheeled bin households

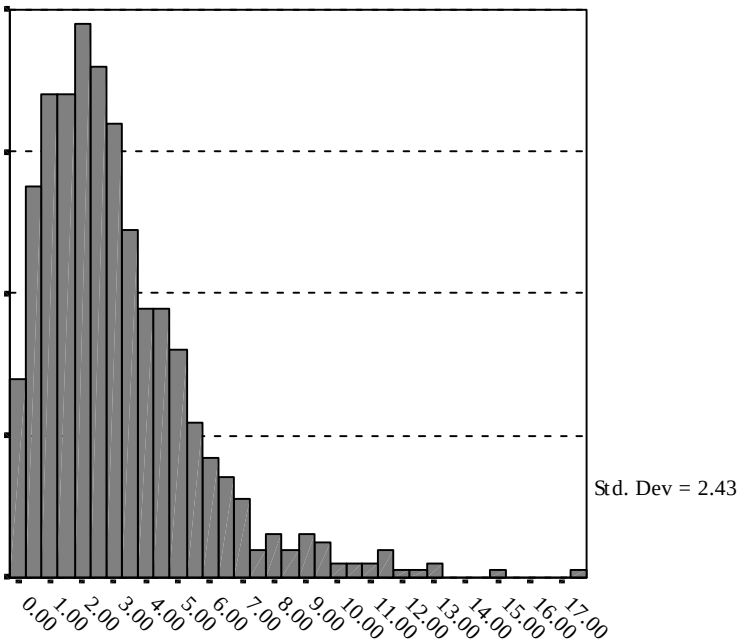


Figure 4.3: Histogram of total non-packaging waste produced by non-wheeled bin households

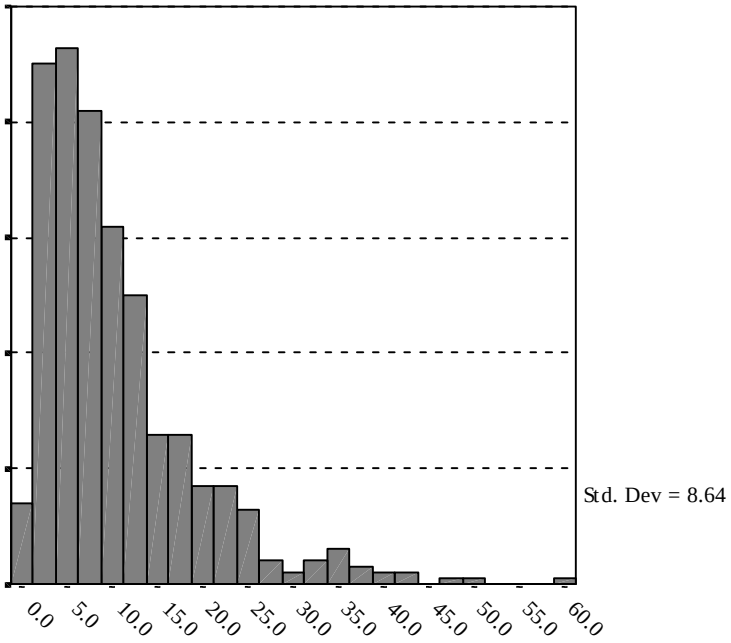
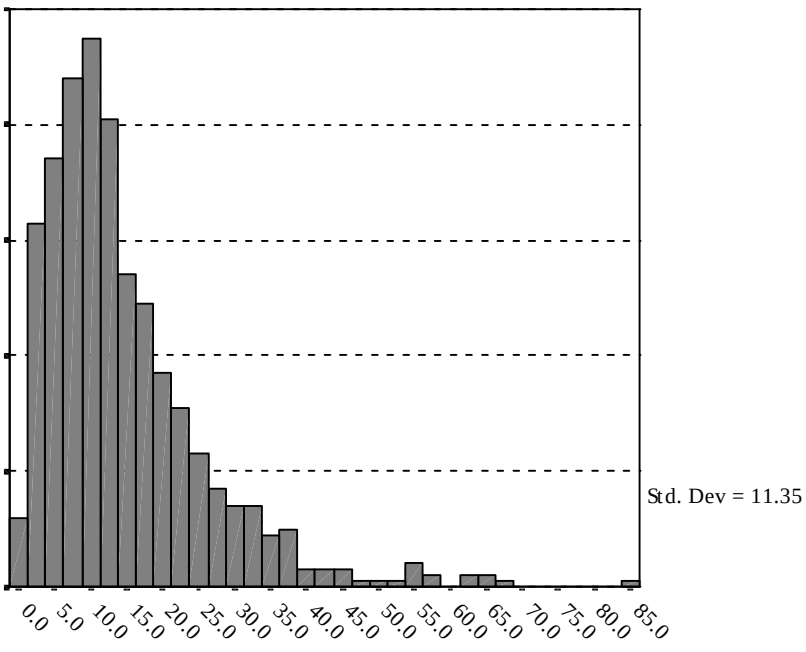


Figure 4.4: Histogram of total non-packaging waste produced by wheeled bin households



The sample was further sub-divided by social group (professional, managerial and skilled/ semi-skilled manual workers versus unskilled, unemployed and retired) to examine variations in total mean weights. **Figure 4.5** shows that the method of waste containment was more significant than social class as a factor influencing the mean quantity of non-packaging waste discarded. This was not the case with packaging waste, where a number of factors influencing quantities were apparent from further analysis of the questionnaire data. The most important of these was the number of people living in the household. The correlation between size of household and mean quantity of packaging waste was similar for wheeled bin and non-wheeled bin households (r=0.33, p= 99.99%). This was not so with non-packaging waste, which again showed significant positive correlation with number of residents in non-wheeled bin households, but no significant correlation in the case of wheeled bin households **(Figure 4.6)**. This finding was largely due to the extreme variation in quantities discarded by wheeled bin households of different sizes: a factor that the simple bars in **Figure 4.6** do not display. Variation in waste quantities from wheeled bon households is discussed further in Section 7 and the variability is shown in **Figure 7.4**. The greater mean quantities of non-packaging waste from wheeled bin households of a given size can be explained by the extra convenience and capacity of wheeled bin collections compared with those served by other methods of collection round waste containment.

Figure 4.5: Comparison of mean packaging & non-packaging waste by social class & method of waste containment

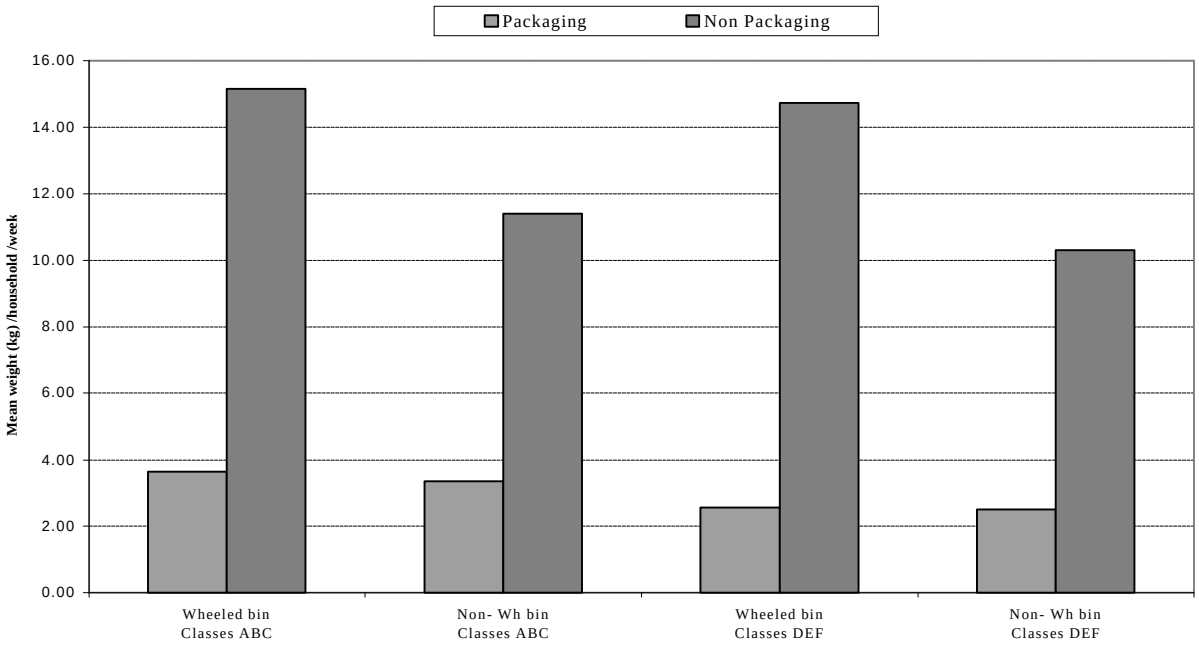
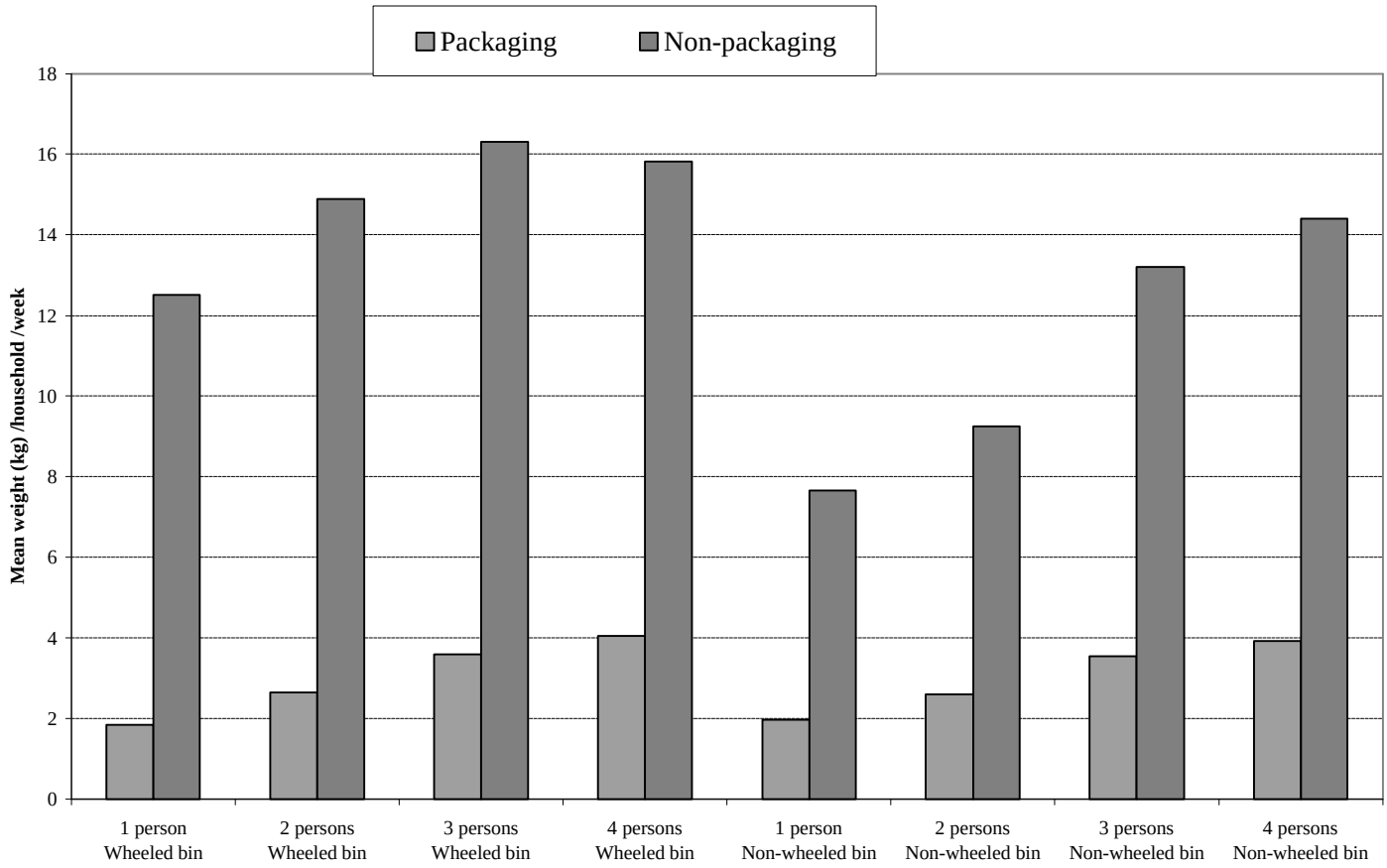


Figure 4.6: comparison of mean packaging & non-packaging waste by method of containment & household size



Variation in the mean quantity of packaging waste was explored further by use of variables derived from the household questionnaire, including questions about recycling activity and household attributes. Despite attempts to build regression models using different combinations of explanatory variable, the overall ability of the models to predict packaging waste discarded in the 'dustbin' remained low. This was partly attributable to the extreme house-to-house variation in total packaging waste recorded. There is considerable variability between households in waste discarded, especially as only one week's refuse was collected for each area sampled. Against this background of random variation it is more difficult to identify systematic variations in the data.

Box 1 (over page) provides an example of one of the 'best-fit' models, with an adjusted 'R-Square' value of 11%. This indicates that 11% of the variation in packaging waste was explained by the three coefficients in the model. The variables 'household size' (number of people) and 'pet ownership' both contributed positive coefficients to the model for self-evident reasons (both of these factors were positively correlated with packaging waste). The third variable: 'access to a garden' provided a negative coefficient in the regression model that is likely to be linked to the particular characteristics of the relatively few urban households in the sample without access to a garden. This finding should not be interpreted as indicating a direct link between the presence of a garden and more packaging waste.

BOX 1: Example of regression model to predict total packaging waste arisings

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.338[a]	.115	.110	2.2593

a. Predictors: (Constant), q16 access to garden, PETS, q19 household size: number of people

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	363.954	3	121.318	23.767	.000[a]
	Residual	2812.619	551	5.105		
	Total	3176.573	554			

a. Predictors: (Constant), q16 access to garden, PETS, q19 household size: number of people

b. Dependent Variable: PTOTPACK

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.003	.418		4.788	.000
	q19 household size: number of people	.540	.078	.283	6.940	.000
	PETS	.639	.197	.132	3.247	.001
	q16 access to garden	-.843	.390	-.087	-2.162	.031

a. Dependent Variable: PTOTPACK

4.3 Variations in primary compositional components

Results of the primary sort are shown for the main packaging elements in **Table 4.1**. As was the case with the total packaging weights, the statistical distribution was highly skewed for each category; thus use of non-parametric statistical tests was more appropriate. For all six packaging categories the median quantity of waste was greater for wheeled bin households compared with non-wheeled bin households (Mann-Whitney U tests: Z values -1.8 to -4.8). The differences were greatest for metal cans (Z= -4.8, p=0.000) and dense plastic packaging (Z= -2.8, p=0.01).

The proportion of total packaging waste accounted for by the primary categories did not differ significantly with containment type. Glass packaging accounted for about 30% of the mean packaging waste total and approximately a quarter consisted of paper and card. Most of the remainder was split evenly between dense plastics (bottles) and metal cans. Plastic film, wood and miscellaneous packaging together accounted for 8% of total packaging by weight (**Table 4.1**).

Variations in the primary packaging components were also examined for households of different size, method of waste containment and social class. All packaging categories apart from 'wood and miscellaneous' were correlated positively with household size.

Table 4.2 presents a statistical analysis of the differences between the median weights of the primary packaging elements by method of waste containment within household size bands. Two person wheeled bin households discarded significantly higher median amounts for three of the packaging categories (plastic film, dense plastics and metal cans) compared with households of the same size using other methods of waste containment. These differences were found to relate partly to social class. More affluent two person households served by wheeled bin collection discarding more of these three packaging categories into their bins (**Figures 4.7 and 4.8**) than either the less affluent households with the same method of containment or their 'ABC1/C2' counterparts in non-wheeled bin areas.

		Paper & Card		Plastic film		Dense plastic		Glass pack		Metal pack		Wood & misc. pack	
		(gm)	%	(gm)	%	(gm)	%	(gm)	%	(gm)	%	(gm)	%
Non-wheeled bin	Mean	**696**	**25**	**210**	**8**	**485**	**18**	**861**	**31**	**498**	**18**	**7**	**0**
	N	516		516		516		516		516		516	
	Std. Deviation	784		284		448		1224		552		67	
	Minimum	0		0		0		0		0		0	
	Maximum	6806		4242		3730		8978		4576		1246	
	Median	484		147		380		420		336		0	
Wheeled bin	Mean	**737**	**23**	**226**	**7**	**559**	**18**	**956**	**30**	**641**	**20**	**22**	**1**
	N	695		695		695		695		695		695	
	Std. Deviation	744		243		520		1312		661		273	
	Minimum	0		0		0		0		0		0	
	Maximum	9014		2087		5300		13927		6848		5280	
	Median	556		166		443		528		488		0	
Total	Mean	**719**	**24**	**219**	**7**	**528**	**18**	**915**	**31**	**580**	**19**	**15**	**1**
	N	1211		1211		1211		1211		1211		1211	
	Std. Deviation	761		261		492		1276		621		211	
	Minimum	0		0		0		0		0		0	
	Maximum	9014		4242		5300		13927		6848		5280	
	Median	520		160		420		462		420		0	

Table 4.2: Comparison of median weight (grams) of primary packaging categories by method of containment within household size bands
- with statistically significant Mann-Whitney U test results indicated by probability values (p)

Household size	Method of Containment	Paper & card	Plastic film	Dense plastics	Glass	Metals	Wood & miscellaneous
1 person	Non-wheeled bin	329	102	238	286	205	0
	Wheeled bin	276	76	210	222	266	0
	significance	ns	p=0.02	ns	ns	ns	ns
2 persons	Non-wheeled bin	398	130	290	395	273	0
	Wheeled bin	485.5	148	360	424	413.5	0
	significance	ns	p=0.09	p=0.01	ns	p=0.03	ns
3 persons	Non-wheeled bin	708.5	166	441	743	458	0
	Wheeled bin	610	190	500	548	566	0
	significance	ns	ns	ns	ns	p=0.1	ns
4 or more persons	Non-wheeled bin	807.5	258	566	846.5	575	0
	Wheeled bin	852	252	602	695.5	615	0
	significance	ns	ns	ns	ns	ns	ns
Totals	Non-wheeled bin	524.5	151	380	481	340	0
	Wheeled bin	540	166	414	460	471	0
	significance	p=0.04	p=0.03	p=0.01	p=0.07	p=0.000	p=0.02

Figure 4.7: Non-wheeled bin households: Mean weight (kg) of selected packaging categories by household size (number of persons) and social class: Combined Environment Agency & 'Going for Green' samples 1996/97

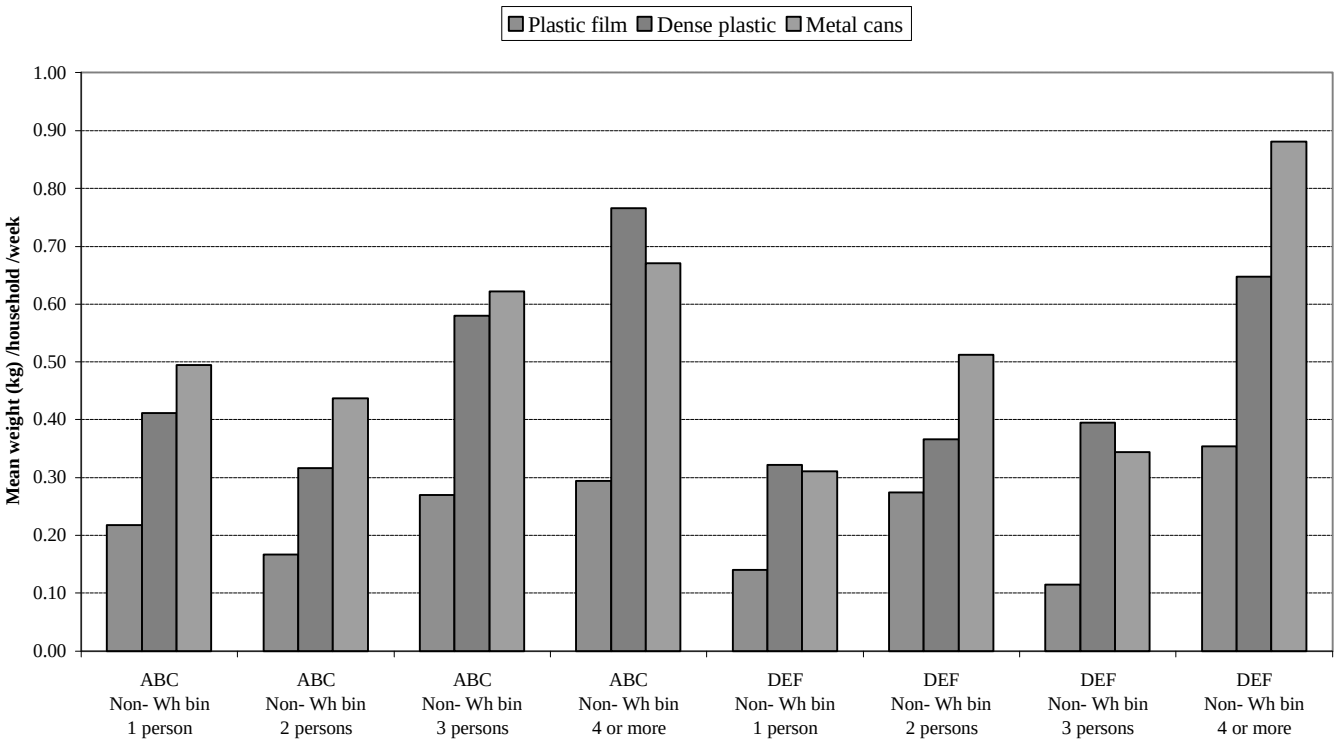
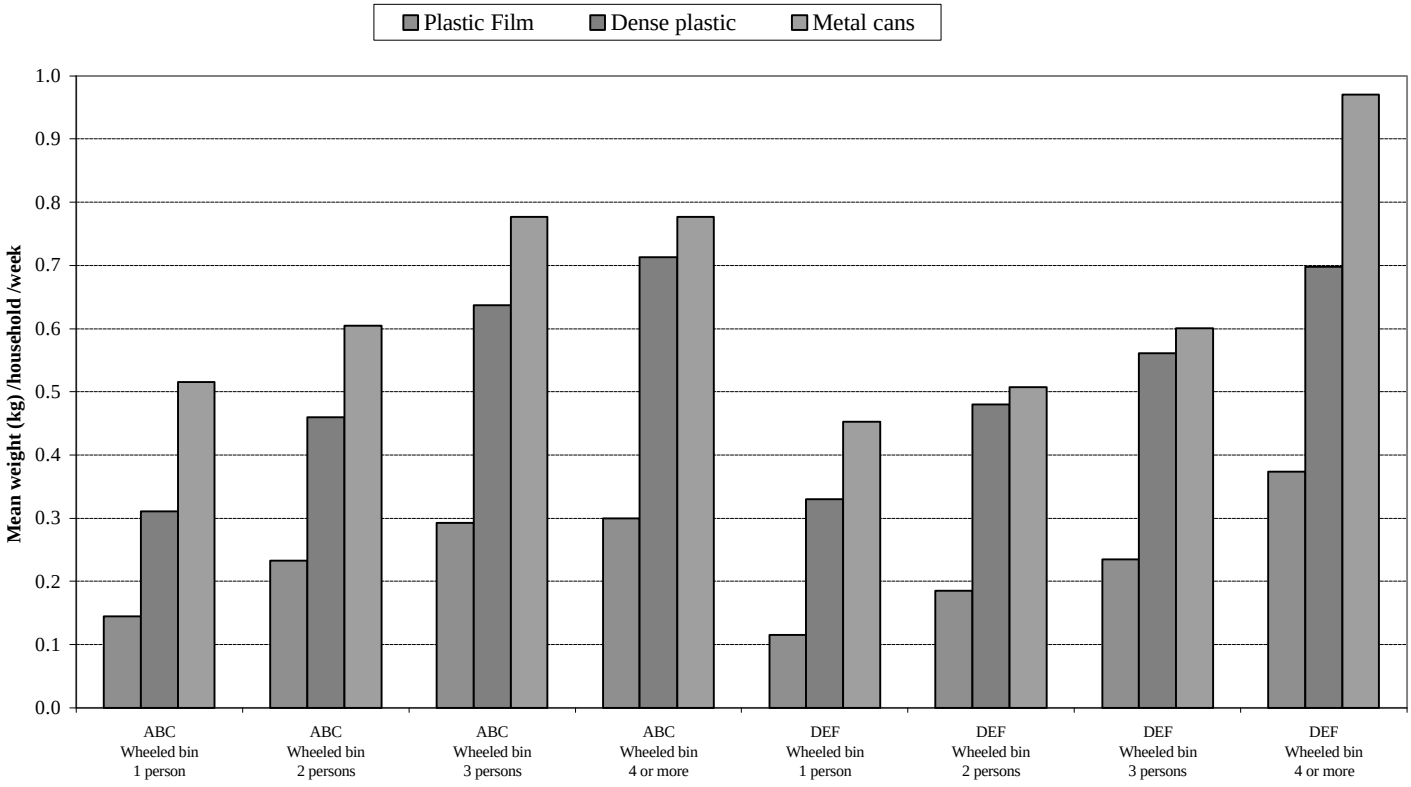


Figure 4.8: Wheeled bin households: Mean weight (kg) of selected packaging categories by household size (number of persons) and social class: Combined Environment Agency & 'Going for Green' samples 1996/97



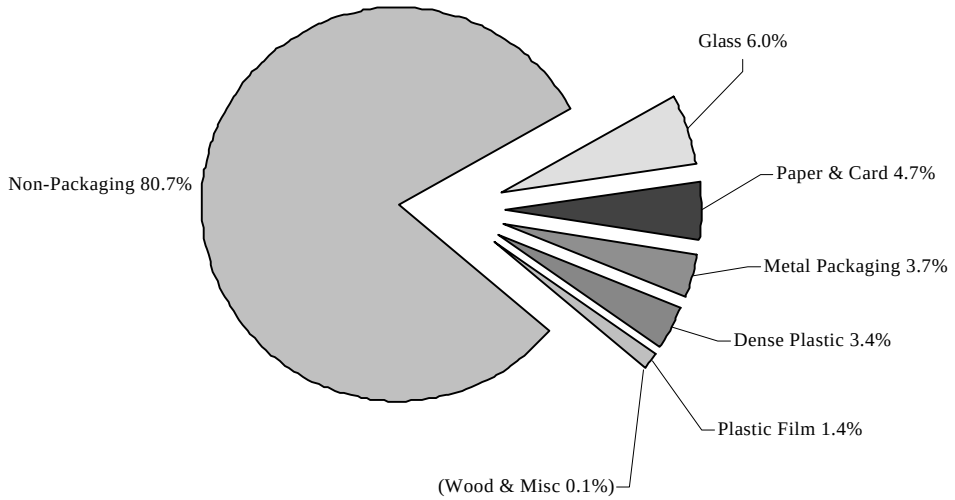
4.4 Overall results from primary compositional analysis

In producing summary results from the primary data, on which to base national estimates, it was necessary to consider both household size and method of waste containment, as both of these factors clearly influenced quantity and type of packaging waste. The approach taken was to weight the results to reflect the national proportion of households on wheeled bin systems (38% of households in 1997/98, DETR/WO in press) and to compare the mean household size in the weighted data with national statistics. In view of the relationship between wheeled bin provision and household size (wheeled bins are more likely in areas with larger households, Parfitt and Jones 1999), the assumption was that if allowance was made for method of containment through the weighting process, then this was also likely to correct for household size. When weighting the primary data to reflect the national proportion of wheeled bin households, the average number of people per household in the sample was reduced from 2.6 (unweighted) to 2.45: close to the national average (ONS 1996 mid-year estimates).

On this basis, weighted results were used to establish the overall proportion of each of the seven packaging categories and for total non-packaging waste in the total 'dustbin' waste. The weighted results in **Figure 4.9** indicated that 81% of household waste

consists of non-packaging materials, such as newspaper, food waste and disposable nappies. Glass packaging accounts for over 6% of the waste stream, paper and card packaging for about 5% and metal cans 4%. Dense plastics and plastic film accounts for 3.4% and 1.5% respectively and other packaging materials, including wood, contributes less than 1% to the average dustbin's total weight.

Figure 4.9: Packaging in collection round household waste
% of total weight of waste, 1996 & 1997 analysis of waste[1]



1 Collection round waste from 1,045 households in 20 local authorities in the United Kingdom (Environment Agency sample: fieldwork May 1996)~ combined with a similar sample of 200 households in 4 local authorities in England from a study commissioned by 'Going for Green' (fieldwork April 1997)

4.5 National estimates from combined primary and secondary data

Having developed a method of weighting the primary level waste data the next stage of the analysis involved application of the same procedure to the more limited secondary data set. Weighting factors were calculated so that the results of the secondary analysis reflected the overall national mix of wheeled bin to non-wheeled bin households.

Results for mean secondary weights (grams) per household are shown in the first column of **Table 4.3**. The secondary totals for each of the seven primary level sort categories deviated quite widely from the mean values obtained from the primary data set alone. As the primary estimates are likely to be more reliable than the same statistics derived from the secondary data set, the secondary data were adjusted so that the mean values of the secondary categories summed to the totals for the seven primary categories (as shown in the third column of **Table 4.3**. The secondary data was therefore used as a means of dividing the values from the primary sort between the sub-categories, by applying the percentages in the second column of **Table 4.3** to the primary level values.

Table 4.3: UK estimates for primary and secondary compositional categories based on Environment Agency and 'Going for Green' combined sample ~ weighted by method of waste containment (wheeled bin v non-wheeled bin)

					1,000's of tonnes
Paper packaging	79	10.5	73	0.5	96
Corrugated card	213	28.4	197	1.3	258
Non-corrugated card(non-grey)	267	35.6	247	1.7	324
Non-corrugated card(grey)	170	22.7	157	1.1	206
Other paper and card packaging	20	2.7	19	0.1	24
Total Paper & Card Packaging	749				
Other plastic film packaging					
Total Plastic Film Packaging					
Expanded brown plastic					
Other dense plastic packaging					
Dense Plastic Packaging					
Other glass packaging					
Ferrous beverage cans					
Ferrous food cans					
Ferrous aerosol cans					
Other ferrous packaging					
Non-ferrous beverage cans					
Non-ferrous food cans					
Non-ferrous closures					
Other non-ferrous packaging					
Wood & Misc. Packaging					
Paper and card non-packaging					
Glass non-packaging					
Plastic film non-packaging					
Dense plastic non-packaging					
Textiles non-packaging					
Ferrous metal non-packaging					
Non-ferrous metal non-packaging					
Miscellaneous combustibles					
Miscellaneous non-combustibles					
			Total non-package waste		
			Total packaging waste		

National estimates for each of the 38 waste categories were calculated by applying the fraction of total weight attributed to each (column 4, **Table 4.3**) to an estimate of total household waste collection round waste for the UK, based on DETR estimates for England and Wales for the year 1997/98. The resulting UK totals are shown in the final column of **Table 4.3**. Overall, it was estimated that UK household waste collection rounds contained 3.7 million tonnes of packaging waste ~ just less than 20% of the total. This estimate excluded packaging contained within materials collected for recycling from households and any packaging waste disposed of through other routes such as at civic amenity sites or from collections of street litter.

The current estimate for the national (England and Wales) recycling rate is 8% (DETR 1999), or about 2 million tonnes per annum. The England and Wales totals for glass, plastics and metal cans can be included in the total packaging estimates, but for many local authorities collecting mixed paper and card, packaging and non-packaging materials cannot be readily distinguished. However, the packaging content can be estimated for the paper and card fraction by applying the ratio of separately collected newspaper / magazines and card to the mixed totals reported by local authorities to the DETR annual survey of municipal waste management. Using this method a total of 380,000 tonnes / year was estimated for packaging materials collected for recycling from households in England and Wales. If this total is extrapolated, pro rata, to the population of the UK, the total estimate is 450,000 tonnes / year is obtained. The combined total for household packaging waste for the UK is:

3.7 million (dustbin estimate: Table 4.3)+ 0.45 (recycling estimate) = 4.15 million tonnes

On this basis the material recycling rate for packaging within the household waste stream was about 11% of dustbin waste (1997/98), which is likely to be an over estimate as the denominator does not include total CA arisings and other household waste collections (yet CA recycling of packaging waste was included in the 450,000 tonnes). However, this estimated rate was not achieved equally across the main packaging materials, as shown in **Table 4.4**. If the 2001 16% minimum material recycling target were applied to the household waste stream in isolation, glass packaging would be the only one of the four categories to have fulfilled it. Paper and card, metal and plastics packaging recycling rates are currently below the rates that would be necessary to reach the 2001 targets.

Table 4.4: Estimated material recycling rates for the packaging content of the UK household waste stream

Packaging category	**Estimated 'dustbin waste' recycling rate**
Glass packaging	32%
Paper and card packaging	6%
Metal packaging	3%
Plastic packaging	Less than 1%

5. COMPARISONS WITH RESULTS FROM THE NATIONAL HOUSEHOLD WASTE ANALYSIS PROJECT

5.1 Introduction

The National Household Waste Analysis Project (NHWAP) collected bulk samples of refuse from household collection rounds of particular neighbourhood types. The bulk samples were sorted into 33 categories, giving sufficient detail for a distinction to be made between most packaging and non-packaging items. Data were collected from 12 local authorities and in some cases the same collection rounds were repeat sampled at different times of year. Further details of the methods and results can be found elsewhere (Department of the Environment 1993) and a critique of the method has recently been published (Parfitt, Flowerdew and Pocock 1999).

5.2 Main comparisons and influence of seasonality

The main compositional results are shown in **Table 5.1** and the raw data from the project have been re-classified into packaging and non-packaging components so that comparisons can be made with Environment Agency and 'Going for Green' data (**Figure 5.1**). Two methodological issues are important to these comparisons:

1. The influence of seasonality on the estimation of the ratio of packaging to non-packaging waste (and therefore on the national packaging estimates)
2. The influence of method of containment on the same

In **Figure 5.1** the NHWAP data have been converted to the primary level sort categories and then displayed for plastic sack and wheeled bin areas alongside the Environment Agency/Going for Green data. Although there are similarities in the mean total weight of waste, the proportion of packaging waste was higher in the NHWAP samples due mainly to the greater quantities of metal and paper/card packaging.

The areas that had been sampled by the NHWAP at different times of year were examined separately for seasonal influences on the relative and absolute quantities of packaging waste. **Figure 5.2** shows that, on the limited evidence of three plastic sack authorities and one wheeled bin authority, there are differences in the proportion of packaging waste which could be attributable to seasonal factors. In the case of plastic sack areas, the influence appeared to relate to fluctuations in quantities of packaged goods consumed (**Figure 5.3**), whereas the predominant influence in the wheeled bin data was variation in the total quantity of non-packaging wastes discarded (**Figure 5.4**). In wheeled bin areas the twice-yearly peak in quantities collected (spring and autumn) is known to relate to peak gardening activity (Parfitt 1997).

Table 5.1: Results from the National Household Waste Analysis Project 1992-93
Analysis of household waste (collection round waste) according to 11 and 33 component classifications

	Percentage by weight				Per cent by weight
11 Component System	Min	Max	Typical	33 Component System	
Paper and card	21.6	54.1	33.2	Newspapers	11.4
				Magazines	4.6
				Other paper	9.5
				Liquid containers	0.6
				Board packaging	3.8
				Other Board	3.1
Plastic film	3.4	8.1	5.3	Refuse sacks	1.2
				Other	4.1
Dense plastic	2.7	10.1	5.9	Clear beverage bottles	0.6
				Coloured beverage	0.1
				bottles	1.1
				Other plastic bottles	1.9
				Food packaging	2.1
				Other	
Glass	2.7	16.9	9.3		1.3
				Brown glass	2.4
				Green glass	5.4
				Clear glass	0.2
				Other	
Ferrous metal	2.8	10.8	5.7		0.5
				Beverage cans	3.7
				Food cans	0.1
				Batteries	0.4
				Other cans	1.0
				Other	
Non-ferrous metal	0.3	3.9	1.6		0.4
				Beverage cans	0.5
				Foil	0.7
				Other	
Textiles	1.1	3.4	2.1		2.1
Putrescibles	13.9	27.8	20.2		3.4
				Garden waste	16.8
				Other	
Miscellaneous combustibles	1.4	13.6	8.1		4.2
				Disposable nappies	3.9
Miscellaneous non-combustibles	0.4	4.2	1.8	Other	1.8
Fines	3.5	12.4	6.8		6.8
TOTAL			*100.0*		*100.0*

(Source: Atkinson and New 1993)

The Environment Agency / 'Going for Green' samples were mostly taken in April and May (**Table 2.2** and **2.3**). Based on the limited evidence of seasonality in the total proportion of packaging waste from the NHWAP data, it is possible that the proportion has been under-estimated in the current estimates. The mean packaging content for plastic sack areas in the NHWAP sample was 30% compared with 23% for the current study, and for the wheeled bin sample: 28% (NHWAP) compared with 21% (current). Since the NHWAP data were collected, household waste recycling rates have increased from less than 5% to 8%. It is also possible that manufacturers may have reduced the weight of packaging items through 'light-weighting' during this period. Such factors could partly explain the larger absolute quantities of packaging waste for the NHWAP 'dustbin' data in **Figure 5.1**. However, the timing of fieldwork relative to seasonal (or weather-related) fluctuations in waste composition is likely to be a more significant factor in explaining these differences.

Figure 5.1: Comparison of mean weight (kg) of primary packaging components & total non-packaging waste:
Environment Agency & 'Going for Green' 1996/97 v NHWAP 1992/93

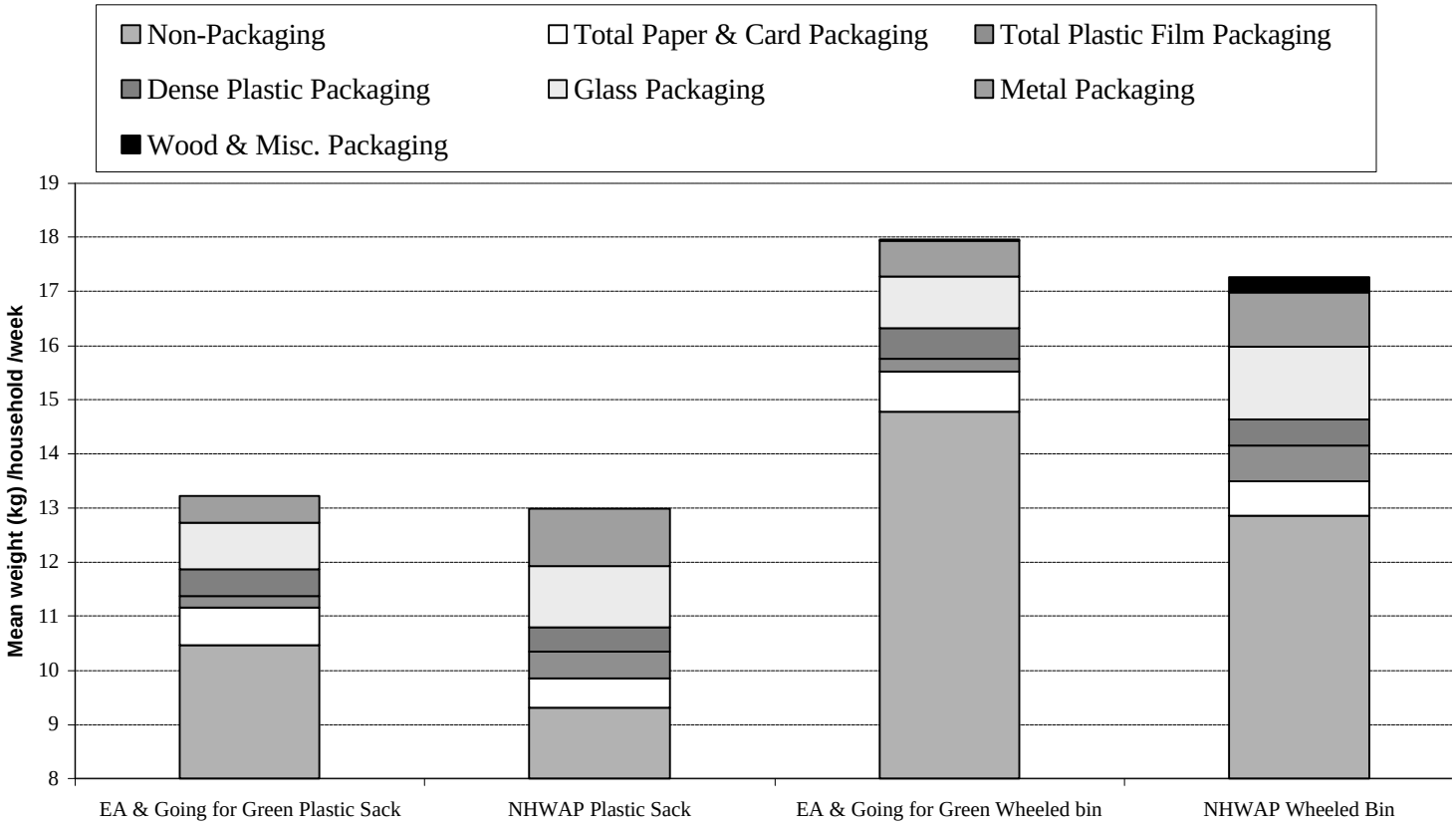


Figure 5.2: Packaging waste as a percentage of total weight of waste
Seasonal comparison of plastic sack & wheeled bin areas
NHWAP data from 4 local authority repeat sampled by season

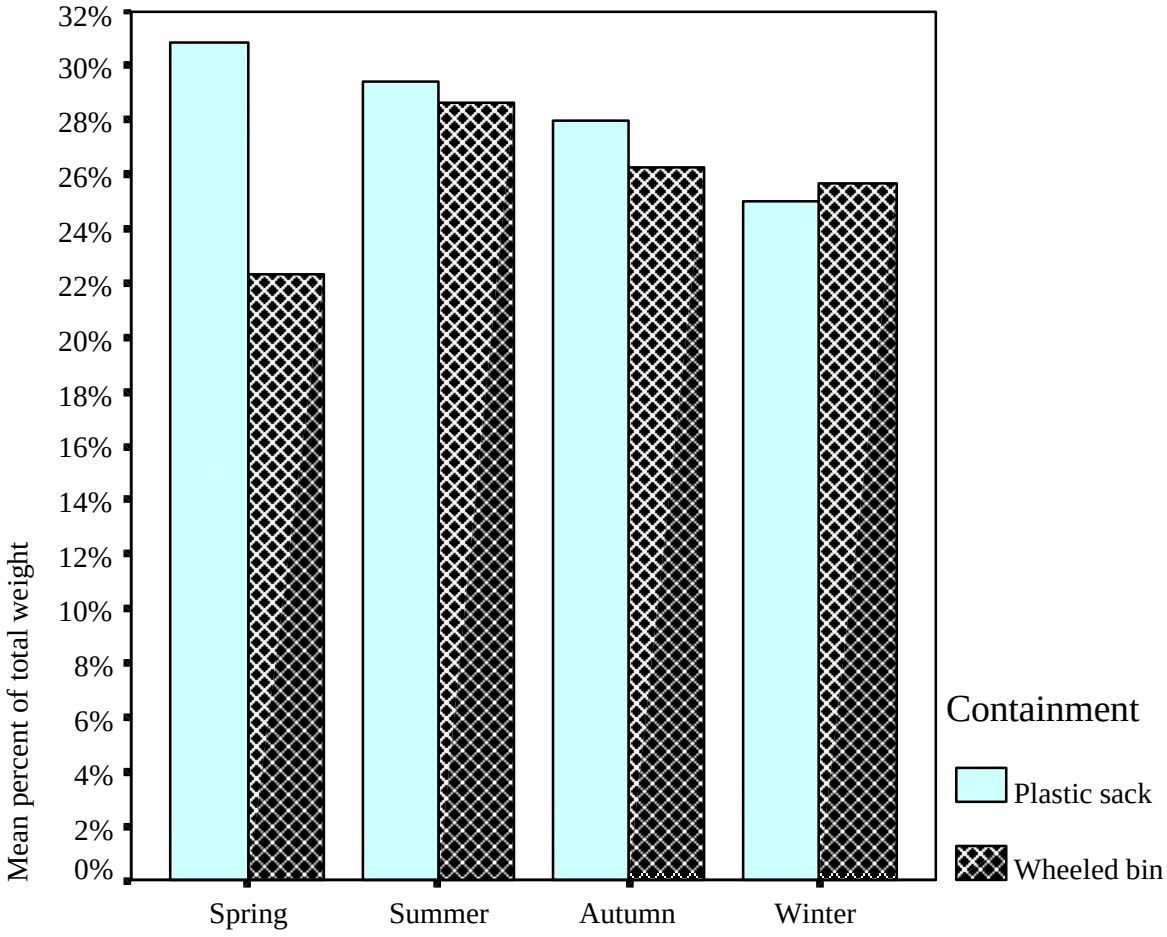


Figure 5.3: Mean weight (kg) of waste /household /week: packaging v non-packaging NHWAP plastic sack samples (St Albans, Charnwood, Gateshead)

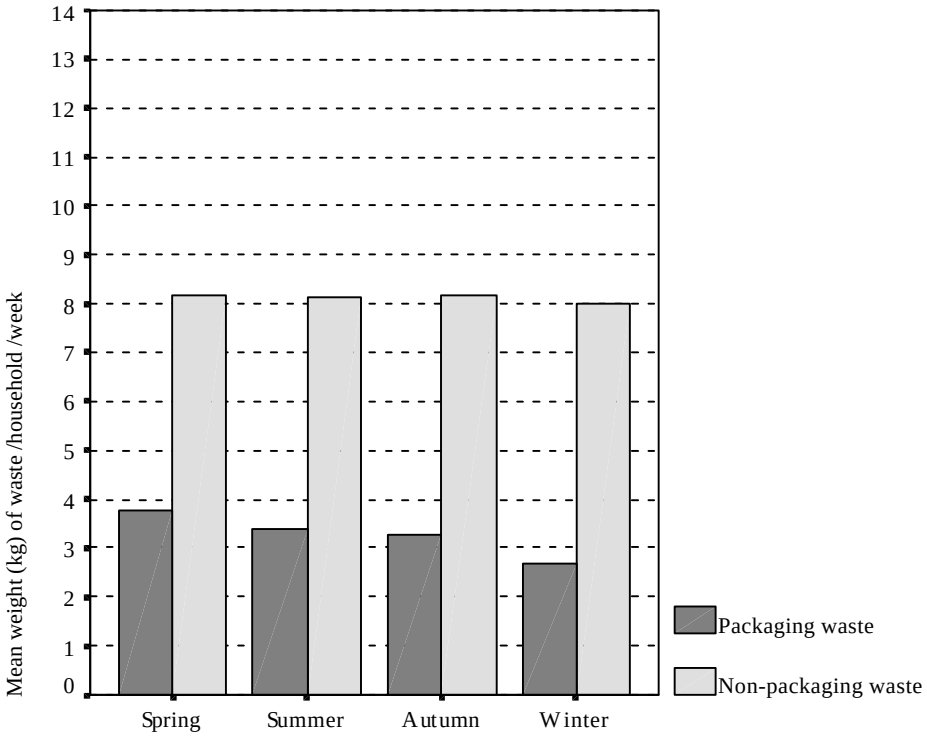
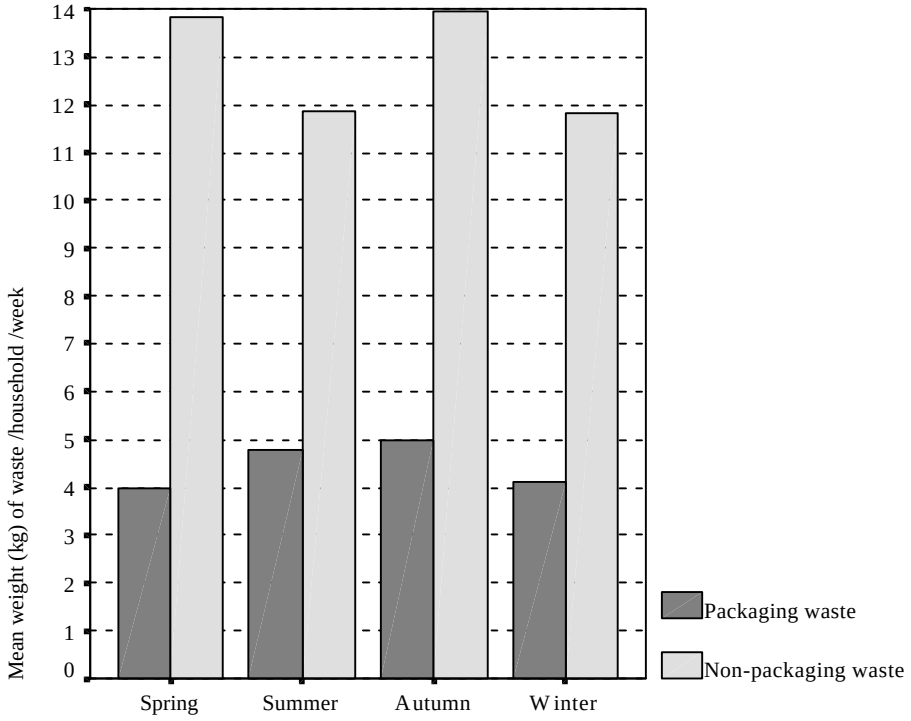


Figure 5.4: Mean weight (kg) of waste /household /week: packaging v non-packaging NHWAP wheeled bin sample (Warrington)



6. SENSITIVITY ANALYSIS AND 'BEST-GUESS' ESTIMATE FOR PACKAGING CONTENT OF UK HOUSEHOLD WASTE

A sensitivity analysis was carried on the current national estimates (**Table 6.1**) to demonstrate the effect of moving from the 20% packaging waste estimate towards 30% to reflect results of the NHWAP. The high estimate, based on 30% packaging waste in household waste, increased the 1997/98 United Kingdom estimate by over 50%. For this reason, it would be desirable to base future estimates of this type on samples taken at different times of year. Indeed, this was one of the recommendations made by the recently published review of household waste statistics (Parfitt, Flowerdew and Pocock 1999: p.131). Without information on seasonal variation, uncertainties about the current estimates cannot be resolved. However, the 'best guess', taking into account an element of under-estimation associated with the timing of the fieldwork, is about 4.5 million tonnes of packaging waste in the UK household waste stream.

Table 6.1: UK household waste packaging estimates: sensitivity analysis

Assumed % packaging in RCV waste	RCV packaging + recycling	UK estimates
20%	**3.7 + 0.45**	**4.15**
25%	**4.8 + 0.45**	**5.25**
30%	**5.8 + 0.45**	**6.25**

7. RESULTS OF ENVIRONMENT AGENCY QUESTIONNAIRE SURVEY

7.1 Introduction

This section focuses on the reported household and consumer behaviour of respondents based on the Environment Agency postal survey, and the links this has with the amount of waste - and packaging waste items in particular - that these households produce.

The postal survey was run in May 1997 and covers socio-demographic characteristics affecting waste generation (household size, access to a garden), recycling activity (both use of Council recycling collection services and use of recycling centres), composting activity, and other waste management issues, such as the form of refuse containment (in particular, the wheeled bin versus sack options) and use of Council Waste Disposal Sites.

The analysis draws on data from two interrelated sources, the postal survey and the refuse compositional analysis. Taking account of missing data, the process of linking the two databases resulted in 572 matched household cases (see **Table 3.1**), although for individual analyses the number of valid cases can reduce further from this (for example where certain questions in the survey were missed out or invalid answers were given).

The first three sub-sections look at basic results from the household postal survey, and the fourth addresses the linkages between the postal survey and the refuse analysis.

7.2 Reported recycling activity

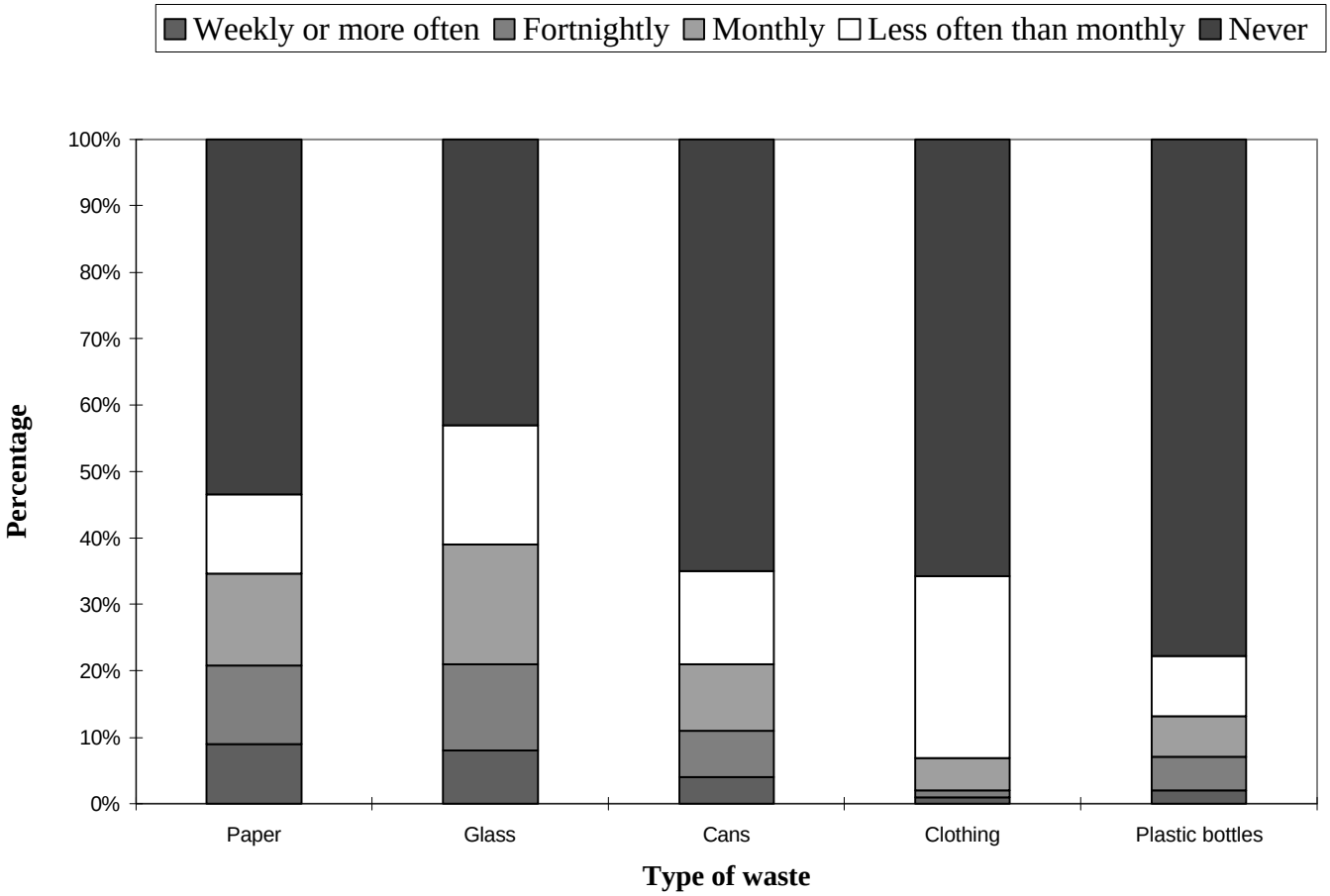
This sub-section focuses on the recycling activity of respondents, in terms of use of recycling centres. It also contains information on household consumption of goods, and analyses of whether such consumption of goods and socio-demographic factors have an effect on use of council recycling facilities. Although information was collected in the questionnaire on kerbside collections of recyclables, only 2 of the 20 areas in the Agency sample were operating such schemes: an insufficient sample to generalise from.

An analysis is also made as to why respondents do not recycle and the willingness of respondents to recycle more in the future.

Use of Bring Scheme Recycling Centres

Respondents were asked how often they took paper, glass, cans, clothing and plastic bottles to 'bring' recycling centres. With the exception of taking glass to bring sites (58% of respondents), most of the respondents did not use recycling centres.

Figure 7.1 How often do you take the following items to a recycling centre?



If monthly or more frequent usage of recycling centres is taken as a definition of a noteworthy level of recycling, it can be seen that the highest participation levels were for glass (38%), paper (35%), cans (21%) and plastic (11%). Participation in textiles recovery was the lowest at 7% of the sample.

The associations between participation in bring recycling and key waste generation variables were examined and a significant link was found in a number of instances. For example in **Table 7.1** it is evident that in households that received the most free newspapers, participation in bring recycling (36% monthly or more) was higher than for those with no free papers (27%). Car ownership was also found to be a significant factor (38% of car owners used bring sites for paper compared with 21% of non-car owners) since so many bring site users took their recyclables by car. Once again, tenure also emerged as a factor with 37% of owner-occupiers recycling paper at bring sites compared with 23% of those who rented.

Table 7.1 How often do respondents take paper to recycling centres?

	Total	How many free newspapers received a week		Access to a car		Tenure	
		Two or more	None	Yes	No	Own	Rent
Base (All)	473	201	48	382	91	392	72
	%	%	%	%	%	%	%
Weekly or more often	9	8	10	8	12	9	10
Fortnightly or monthly	26	28	17	30	9	28	13
Less than monthly/never	66	65	73	62	79	63	78

There was undoubtedly a socio-economic factor in paper recycling at bring sites, associated with car ownership and tenure. This is also reflected in the analysis for metal can recycling at bring centres, where the respondents' social classification was significant, as seen in **Table 7.2** below.

Table 7.2 How often do respondents take cans to recycling centres?

	Total	Social class		Access to a car		Tenure	
		Non manual	Manual	Yes	No	Own	Rent
Base (All)	388	126	96	323	65	320	62
	%	%	%	%	%	%	%
Weekly or more often	4	6	6	4	6	4	7
Fortnightly or monthly	17	18	10	18	9	18	7
Less than monthly/never	79	76	83	78	85	78	87

Following a similar analytical routine, **Table 7.3** shows the main factors affecting people's likelihood of recycling glass at bring sites. Once again, car ownership and tenure emerged as important. This kind of analysis could be extended further in more detailed research; the purpose of reporting the findings here is principally illustrative, to show the capability of this approach to enhance understanding of what influences people's waste management behaviour.

Table 7.3 How often do respondents take glass to recycling centres?

	Total	Access to a car		Type of home		Tenure	
		Yes	No	Detached/ semi/ bungalow	Flats	Own	Rent
Base (All)	494	405	89	367	30	409	78
	%	%	%	%	%	%	%
Weekly or more often	8	8	9	6	20	8	9
Fortnightly or monthly	31	32	24	33	30	32	21
Less than monthly/never	61	60	67	61	50	60	71

The survey contained a question on the reasons for non-use of bring recycling facilities. Non-recyclers gave the following broad reasons, which focus on convenience, accessibility and their own inclination. The predominance of convenience issues underscored link between recycling behaviour and the waste management infrastructure.

Table 7.4 What are your main reasons for not recycling waste at recycling centres or banks?

n=332 responses (Respondents could give more than one answer)

Reason for not recycling	**n**	**%**
Too far away/not enough banks/don't know where banks are	84	25
Lack of/ expense of transport	54	16
Not enough time	38	11
Other	34	10
Not enough/nothing to recycle	30	9
Too old	25	8
Too lazy	17	5
The Council collects	17	5
Not enough space	15	5
Use charity shops not banks	12	4
No incentives	3	1
Waiting for collection service	2	1
Pay taxes to have it collected	1	1
Total responses	332	100

How could Respondents be Encouraged to Recycle More than they do at Present?

Respondents who reported that they never used recycling centres or bottle banks were asked if anything would make them recycle more than they did at present.

There was a fairly even split between those who felt that there were steps that could be taken to increase their level of recycling (53%) and those that felt that there wasn't anything that would encourage them to recycle more (47%). This suggests that there is a limit to what can be done to increase the public's recycling behaviour, and some people cannot be expected ever to do much.

Table 7.5 What would make you recycle more than you do at present?

n=330 responses (Respondents could give more than one answer)

Reason to recycle	**N**	**%**
Council collection	120	36
Closer/better banks	80	24
Council provides better containers	66	20
Other	30	9
Better collection service	25	8
More time	5	2
Payment for materials	4	1
Total responses	330	100

There were a number of factors that would encourage respondents who felt they could increase their recycling activity. Introduction of kerbside collection of recyclable material was given as the main way respondents who never recycle would do so in future. The second most cited reason, the provision of closer and better recycling banks, ties in with the factors given earlier that current recyclers said would help them recycle more than at present. These 'convenience factors' appeared to be of greater importance than receiving financial reward for recycling materials.

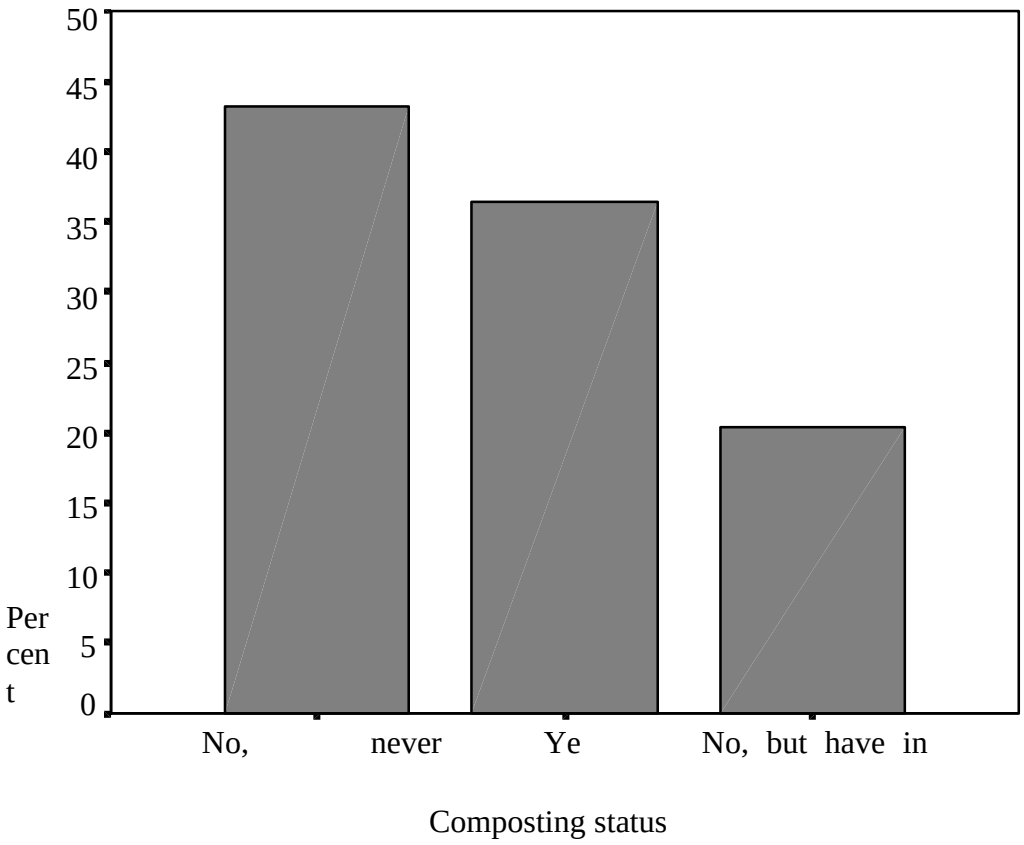
7.3 Composting

Prevalence of Composting Activity

This section analyses current composting activity of respondents as well as analysing whether such activity varies according to socio demographic factors and patterns of behaviour.

Figure 7.2 Do you compost any of your kitchen or garden waste?

n=628



In all, just over a third (37%) of the total respondents in the survey composted some of their waste. This result was close to those of the DETR omnibus survey carried out in 1998 where 38% of respondents said they had composted waste at home over the last 12 months. Most of the composters (32% of the sample) had a compost heap or special compost bin but others had allotments and composted waste in other ways as seen shortly. Of the 63% of respondents who were not currently composting, 20% had composted in the past, while 43% had never composted.

Of the respondents who did compost (n=219), 64% composted both kitchen and garden waste, with 32% composting just garden waste; 7 respondents out of the 219 composted kitchen waste only.

Among respondents who did not compost (n=485) 42% put their garden waste out with other rubbish to be collected by the Council, 24% took garden waste to the Council's waste disposal site and put it in a skip for garden waste. Thirteen percent took it to the waste disposal site but put it with the general rubbish, while 44 respondents out of the 485 (9%) did not produce any garden waste and 28 respondents (6%) said that they burn it on a bonfire.

Table 7.6 Do you compost any of your kitchen or garden waste?

	Total	Type of home		Access to an allotment		Tenure	
		Detached/ semi/ bungalow	Flats	Yes	No	Own	Rent
Base (All)	628	474	34	19	609	518	99
	%	%	%	%	%	%	%
Yes	37	41	18	68	36	39	23
No, but have in the past	20	22	18	26	20	20	20
No, have never composted	43	37	65	5	44	41	57

Composting rates were highest, as seen in **Table 7.6**, for people living in detached, semi-detached housing (including terraced housing) or bungalows (41%) and for those having allotments (68%).

Does whether respondents compost any of their kitchen or garden waste vary according to access to an allotment?

There is a statistically significant relationship ($p<.01$) between respondents in households with access to an allotment and composting kitchen or garden waste.

When examined further, the combined percentages of those having access to both a garden and an allotment by whether people composted their waste were as follows:

- Had access to garden and allotment - 69% composted waste
- Access to garden but not allotment - 36% composted waste
- Access to allotment but not garden - 66% composted waste
- No access to either allotment or garden - 22% composted waste

Evidently, composting amongst allotment users was twice that for garden users. It is interesting that a fifth of people without access to either garden or allotment claim to compost waste. There may be a number of reasons for this, for example:

- Use of composters or digesters for kitchen wastes
- Use of neighbour's composters.
- Taking compostable kitchen waste to central composting facilities e.g. at CA sites
- Inaccurate reporting in the questionnaire

When examined in detail, composting activity was found to be higher amongst people who frequently cooked fresh vegetables. Interestingly when social class was examined,

Composting was higher amongst manual social groups (37%) than amongst non-manual (33%).

Do you compost any of your kitchen or garden waste?

	Total			Social class	
		Every week	Less than once a week	Non manual	Manual
Base (All)	628	600	20	199	160
	%	%	%	%	%
Yes	37	37	20	33	37
No, but have in the past	20	21	20	26	16
No, have never composted	43	43	60	42	47

Finally, the relationship between wheeled bin provision and likelihood of people composting their waste was explored. It is frequently suggested amongst waste managers that wheeled bins result in the diversion of more garden and putrescible waste into the collection round waste stream. With the targets in the Landfill Directive requiring a reduction in the quantity of untreated organic waste entering landfill, this is a significant issue. It was found that households with wheeled bins were indeed slightly less likely to compost their waste (35.5%) than households with sack or other method of collection (38.0%).

Other factors however are at work in this analysis, as considerations covered elsewhere have explained, in that the provision of wheeled bin collection is associated with premises of a particular type. These are likely if anything to mask the size of the wheeled bin effect, as households likely not to have wheeled bins (flats and small urban terraces) are also the households least likely to have substantial gardens and therefore are the least likely all other things being equal, to compost their waste. If this effect could be removed, the impact of the wheeled bin in reducing composting could be expected to be even more pronounced.

7.4 The effect of household behaviour on the generation and

A key feature of the research design is the prospect of being able to link household consumer behaviour (as stated in the postal questionnaire) and the wastes arising from

illustrative tests of the data.

Total collected household (dustbin) waste

One way of examining the link between total waste generation and buying behaviour is

each week' as a surrogate for weight of waste. **Table 7.8** shows firstly that the quantity of sacks used increased substantially for larger households. On average for the sample as a whole, only 19% of households used more than 3 sacks a week. This rose to 49% for households of 4 or more people, compared with only 10% for households of 3 people or less.

Similarly, households who buy most of their grocery products from local corner shops were likely to generate fewer sacks - only 11% generated more than 3 sacks compared with 28% of those who bought mainly from large supermarkets. There will of course be a link here between age and household size (typically, corner shop users are older people living alone or in small households).

Table 7.8 If you use sacks, how many do you actually use each week on average?

	Total	Number of people in household		Buying behaviour	
		One to three	Four to eight	Local corner shops	Large out of town supermarkets
Base (All)	272	199	66	27	14
	%	%	%	%	%
One to three	81	91	52	89	71
Four to six	15	8	41	7	21
Seven to twelve	4	2	8	4	7

Similarly, it can be seen in **Table 7.9 (over)** that people who cooked pre-packed meals generated more sacks, with 24% of those cooking pre-packed meals weekly or more producing over 3 sacks, compared with 12% of those never cooking pre-packed foods. There will again be an underlying influence of age and household size in this analysis (inter-correlations, such as these, are discussed further at the end of Section 7).

Table 7.9 If you use sacks, how many do you actually use each week on

	Total	FREQUENCY OF COOKING PRE PACKED MEALS		FREQUENCY OF COOKING TINNED FOOD	
		Every week	Never	LESS THAN ONCE A WEEK	Never
Base (All)	272	117	58	80	21
	%	%	%	%	%
One to three	81	76	88	90	86
Four to six	15	21	9	8	10
Seven to twelve	4	3	3	3	5

Compositional data and questionnaire data

Method

This section contains cross-analyses of questionnaire responses and data relating to the amount of refuse respondents throw away, in order to determine whether socio-demographic characteristics of respondents and their behaviour in relation to recycling and composting have any effect on the amount and type of refuse they produce.

The questionnaire responses of respondents have been cross-analysed with data from the broader waste categories of the primary sort:

- Total weight of sample
- Paper and card packaging
- Plastic film packaging
- Dense plastic packaging
- Glass packaging
- Metal packaging
- Wood packaging and miscellaneous
- Non packaging residue

Data are available for all households in these categories, whereas it is only available for a limited number (128) from the secondary sort (see **Figure 3.2**).

Of households in the original field survey sample, those analysed in this section exclude the following categories, to ensure the resulting data analyses are as complete as possible:

- Households from whom a self completion questionnaire was not received, as there was no way of cross analysing the weight data and questionnaire responses;

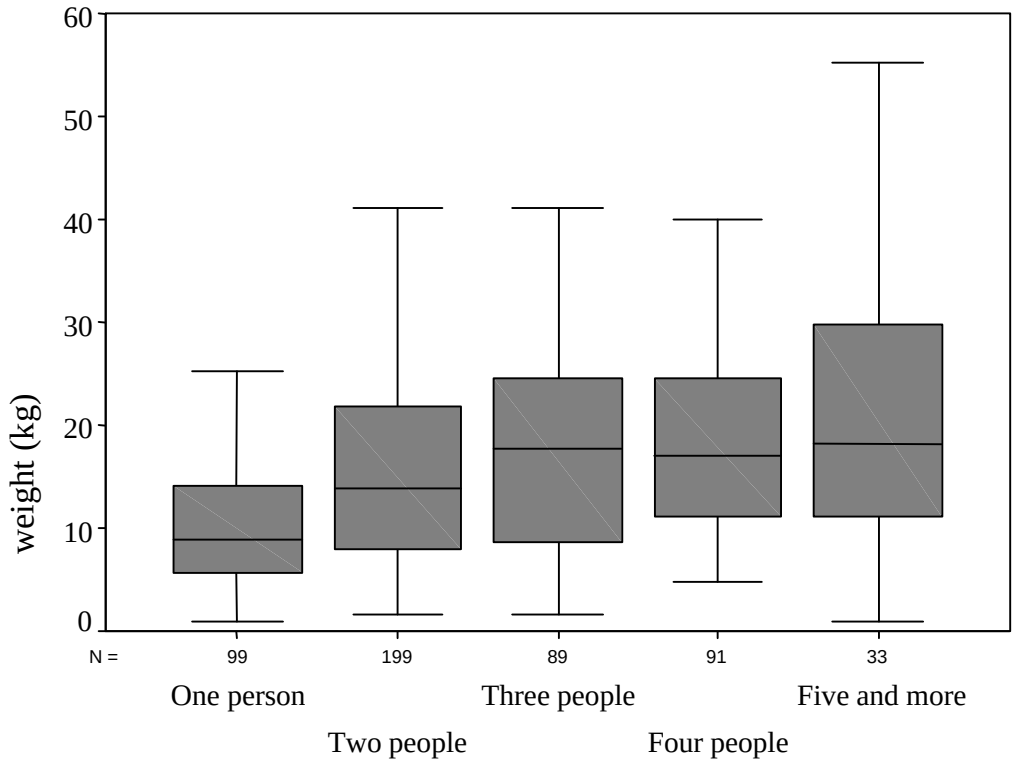
- Postal survey respondents in households for whom no refuse data was present, as there was no way of cross analysing the refuse data and questionnaire responses;

- Respondents who moved into the property after the refuse analysis had been carried out, as their responses would bear no relation to the refuse data collected previously.

This left 572 valid cases in the Agency dataset, of which some were eliminated in the more detailed analysis if the answers to specific questions were missing.

Simple statistical tests (t-tests) were used to establish whether or not differences observed in the sample data were likely to have occurred through chance. Missing values were excluded from any analysis unless otherwise stated.

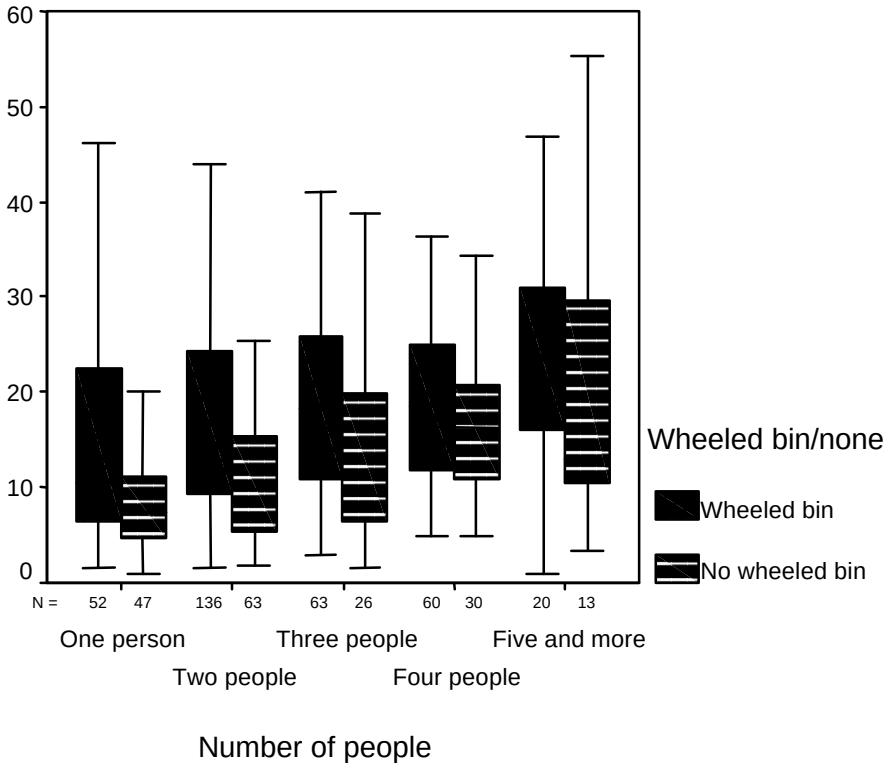
Figure 7.3 Do households with more people living in them produce more total waste?



The relationship between household size and average waste quantities has already been discussed for the combined Going for Green and EA samples (**Section 4)** in relation to social class and method of containment for packaging and non-packaging wastes. **Figure 7.3** shows the overall relationship between the number of people in the household and the total amount of waste produced for the EA sample. The 'box-plots' in **Figures 7.3** and **7.4** display the high degree of scatter in the data for households of different size. It is notable that the interquartile ranges (the range containing 50% of

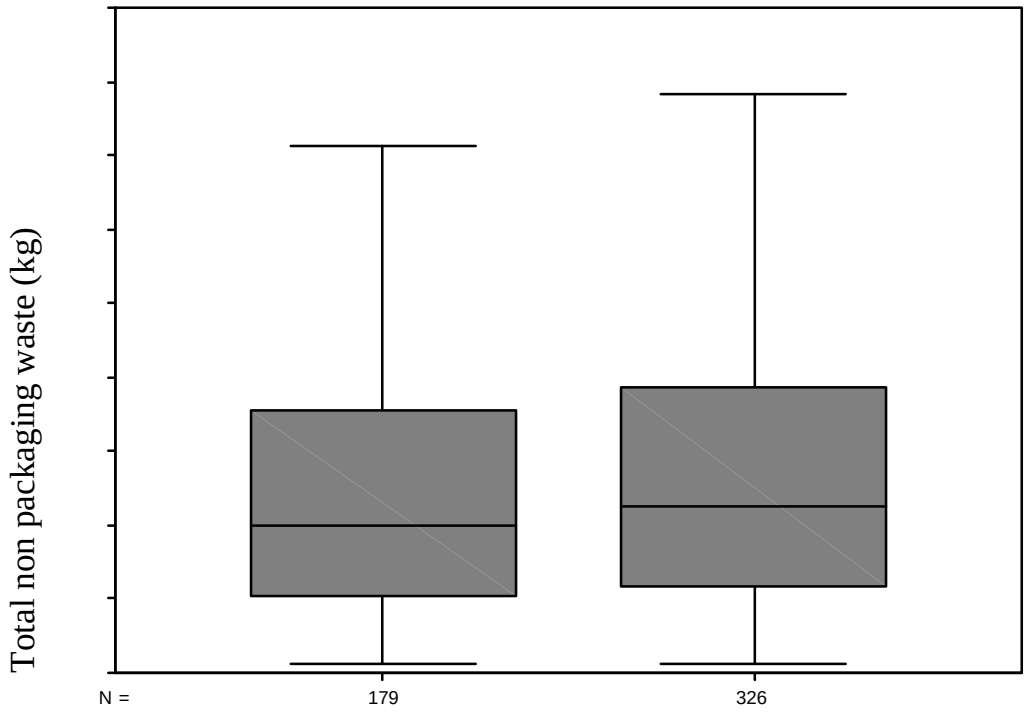
the values, represented by the boxes) are larger for wheeled bin households of all sizes up to and including four people, compared with those households served by other methods of containment. The quantity of dustbin waste discarded by wheeled bin households was therefore inherently more variable than for other households. This ties in with the finding in Section 4 that for total non-packaging waste from wheeled bin households, no correlation was found in the combined EA and Going for Green dataset with household size (**Figure 4.6**).

Figure 7.4 Do households with wheeled bins put more waste out for collection than non-wheeled bin households?



Moving from the analysis of the total measured weight of arisings, the next set of analyses deal with some of the dimensions of the individual primary packaging components in the waste and associations with reported behaviour from the postal questionnaire.

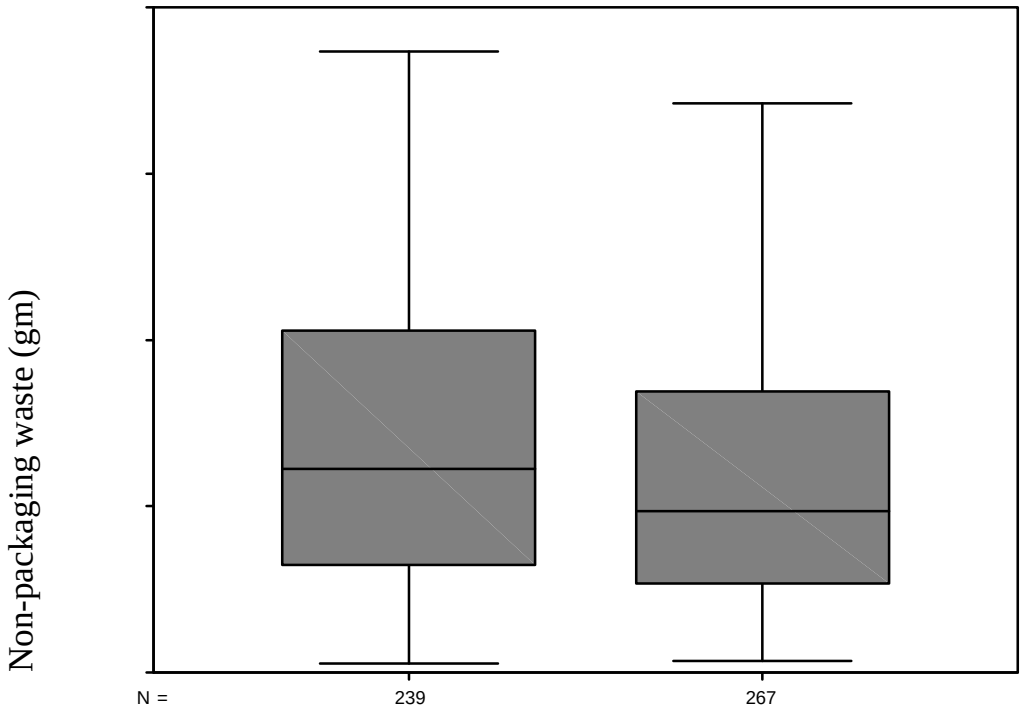
Figure 7.5 Do people who compost their waste produce less kitchen or putrescible waste (non-packaging waste) than average?



The compostable element of the waste stream was not examined in detail and lies within the aggregate ‘non-packaging’ fraction of the waste as measured in the primary sort (**see Table 2.3**). Although it was measured in the secondary sort, the limited sample where secondary categories (applying only to a fifth of the total sample) were tied to respondent households were too small to permit valid statistical analysis. However, as the compostable waste was the largest part (around 40%) of this fraction it is reasonable as a 'first approximation' to use this 'total non-packaging' parameter as the basis for a rough and ready test of whether composters produced less compostable waste for disposal.

Respondents who did not compost any of their kitchen or garden waste did indeed produce the larger amount of non packaging waste, and the largest median amount of waste, although the difference among the non composters and composters was only slightly statistically significant; composters produced an average of 12.98 kg per week of non-packaging waste compared with 14.89kg for non-composters (**Figure 7.6**). This would imply that composters diverted an average of 2kg per week from their waste arisings via composting, which was about 15% of the average total household waste arisings figure. Although this test is a rough and ready one, it is highly significant in the wider policy context, since the amount equates to typical dry recycling diversion rates.

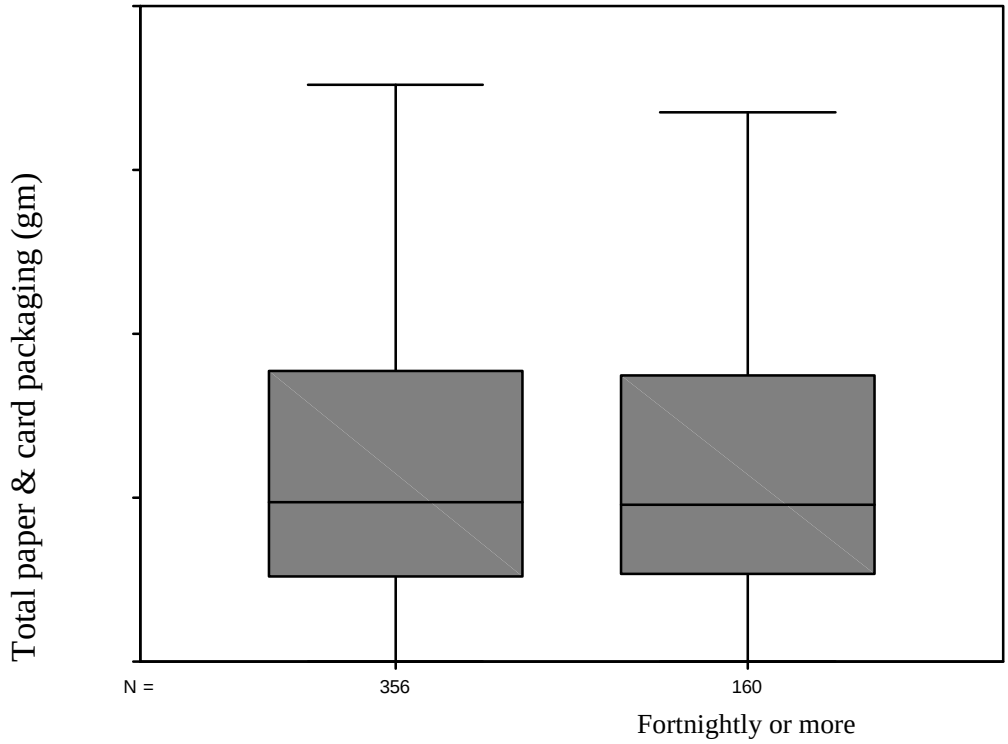
Figure 7.6 Do respondents who live in households who cook fresh vegetables more often produce more kitchen or putrescible waste (non-packaging) waste?



Respondents who live in households who cooked fresh vegetables daily as opposed to less than daily produced a smaller amount of the aggregate non-packaging waste category, and produced a smaller median amount of non-packaging waste. The difference between these categories and the amount of waste produced were significant at the 95% confidence interval. The average for those cooking fresh vegetables daily is 12.3kg a week, compared with 16.2kg for those cooking less than daily. This at first sight is surprising in that respondents who cooked fresh vegetables more often would be likely to throw away more peelings from vegetables. However, because such respondents cooked fresh vegetables more often, they may have produced less other non-packaging waste such as other kitchen waste. They are also more active composters of waste as seen earlier.

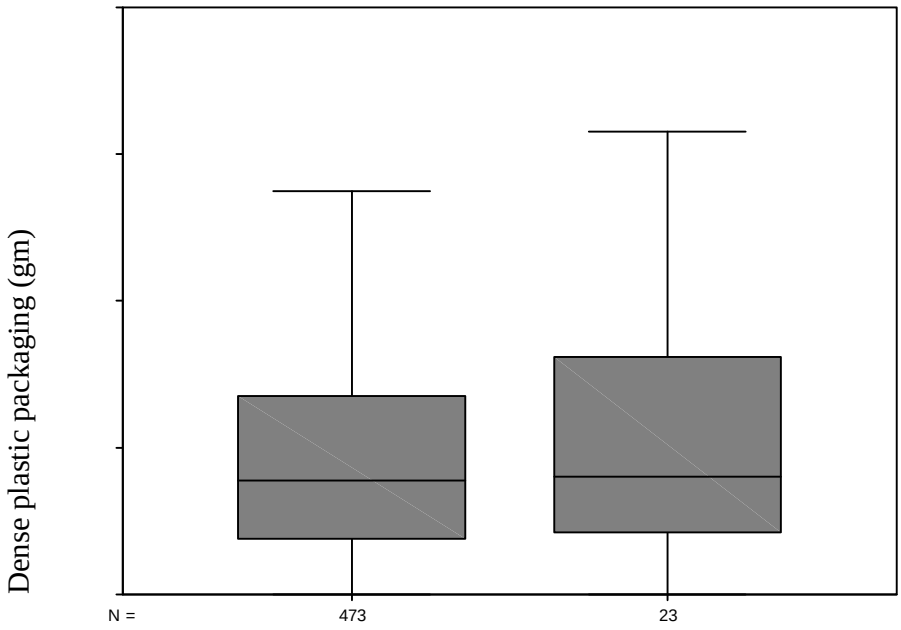
Next, quantities of paper and card packaging were analysed in relation to the frequency of recycling (**Figure 7.7**). Examining reported household behaviour and the observed contents of their waste might at first sight appear to be attempting to prove the obvious. However it is an important validation check on the data and shows the potential of the method to gain a real insight into the way that household waste gets produced. By developing a knowledge base at this level, it is possible to predict with greater confidence the future effects of changes in both household consumer behaviour and their waste management behaviour on the resulting waste streams generated.

Figure 7.7 Do people who recycle paper have less paper and card packaging in their household waste?



The analysis included whether households who recycle paper had less paper and card packaging in their waste, using reported bring recycling behaviour only, as the paper in kerbside recycling collections was aggregated into the waste data for analysis. The average paper and card packaging for paper recyclers was 0.65kg compared to 0.69kg for non-recyclers. All things being equal, this implied that little paper and card packaging was being diverted through bring recycling. This is hardly surprising as most paper recyclers using bring schemes confine their recycling to newsprint only and many paper banks ask for card and other paper packaging to be excluded. Kerbside schemes are often more receptive about card and the recovery of card packaging (the largest weight fraction of the primary paper and card category) was likely to be higher through this route.

Figure 7.8 Do respondents who live in households who cook pre packed meals more often produce more plastic packaging waste?

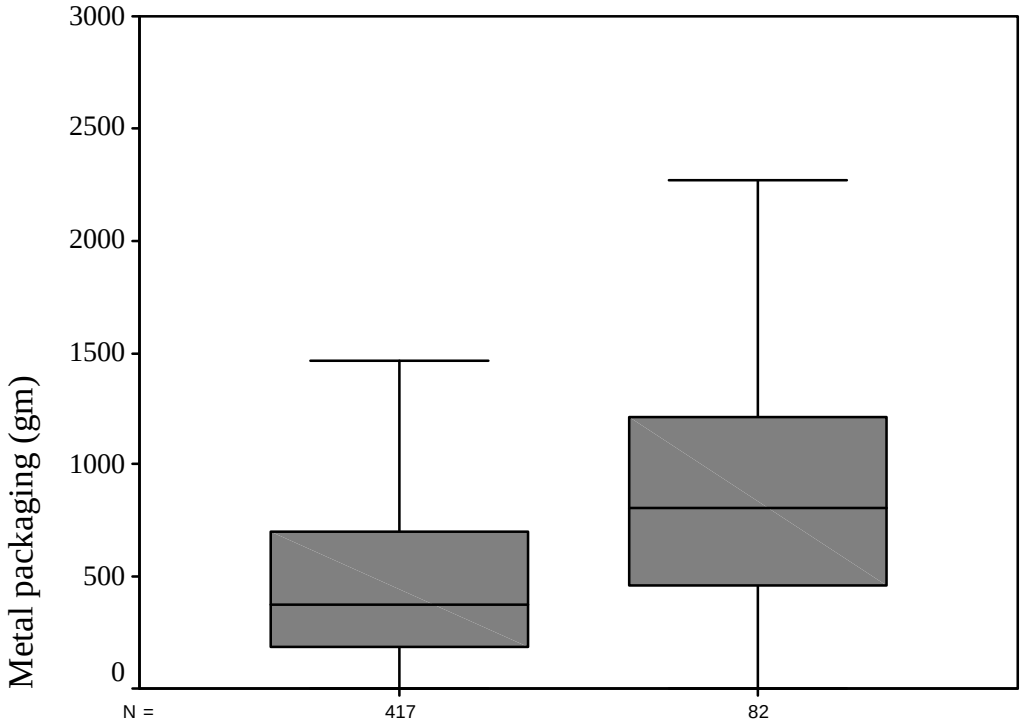


How often does the household cook pre packed meals?

Respondents in households who cook pre-packed meals daily produced a larger amount of dense plastic waste than those who cooked such food less than daily. Those who cooked such food daily also produced a larger median amount of dense plastic waste - an average of 0.6kg a week compared with 0.5kg for those cooking pre-packed meals less than daily.

This may reflect the larger quantity of plastic waste to be found in such households, resulting from the frequency of cooking pre-packed meals and disposing of associated plastic packaging.

Figure 7.9 Do respondents who live in households who cook tinned foods or tinned vegetables more often produce more metal packaging waste?



How often does your household cook tinned foods/vegetables?

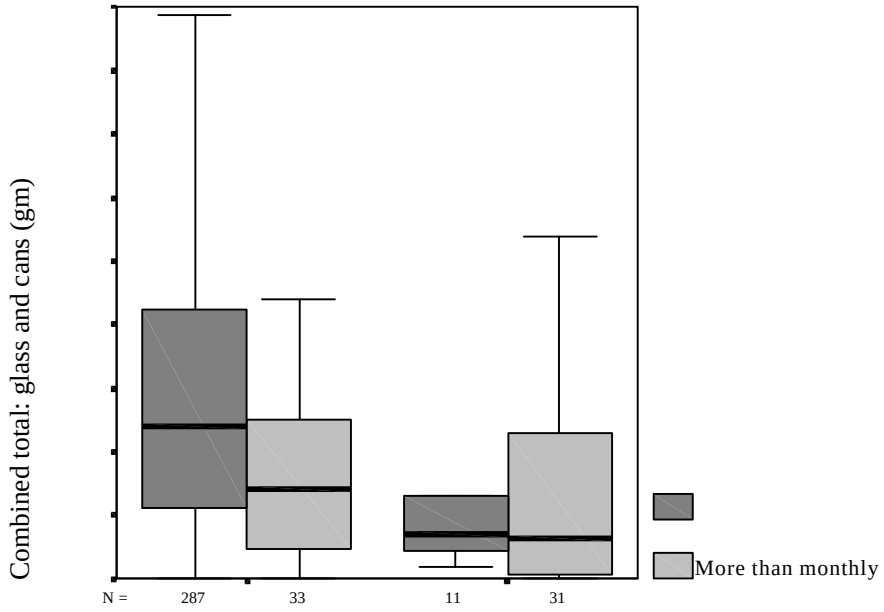
Respondents in households who cooked tinned foods or vegetables daily produced a much larger amount of metal packaging waste, and a larger median amount of metal packaging waste than respondents in households who cooked such food less than daily. Households who cooked tinned foods daily generated 0.9kg of metal packaging a week compared with 0.5kg for those cooking tinned foods less frequently. This may reflect the larger quantity of metal packaging waste produced as a result of cooking habits in these households. Again this analysis would be more revealing if undertaken at the secondary sort level, as might be possible in a survey with a higher number of matched waste and household survey samples.

Do people who recycle throw less recyclable packaging wastes away?

In order to undertake an overall test of the impact of recycling behaviour, some aggregate parameters were created. First a composite recycling behaviour variable was constructed by categorising people who recycle cans and glass into a dichotomy consisting firstly of those who put out cans or glass separately for the Council's recycling collections or took each of these items to a recycling centre weekly or more often and fortnightly, as people who recycle 'more than monthly'. Other respondents were labelled people who recycle 'monthly or less'.

Next a composite 'recyclable waste packaging category' was created, which consisting of cans and glass added together. The results of analysing the total cans and glass weight against the recycling variables are shown in **Figure 7.10**.

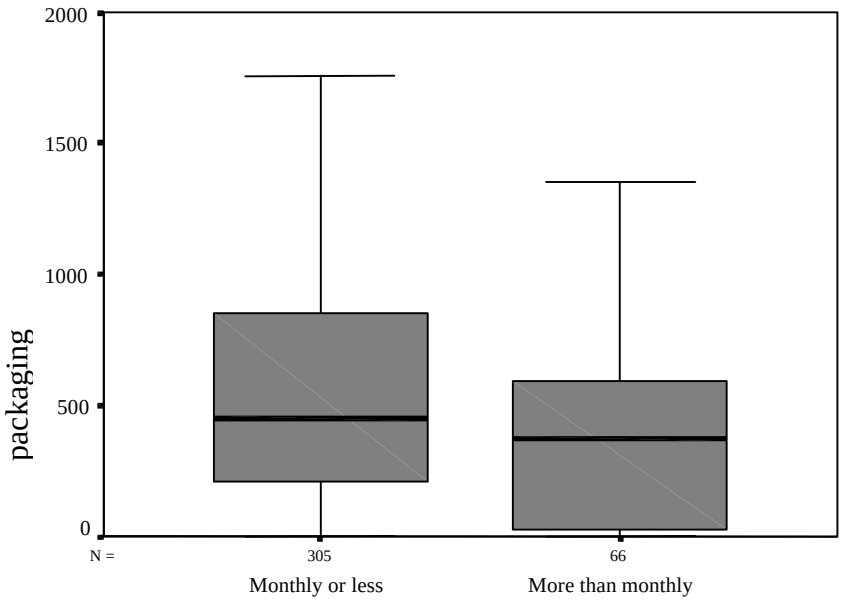
Figure 7.10 Do people who recycle throw less recyclable packaging wastes away?



It can be seen that those who recycled both cans and glass monthly or less frequently, had the most cans and glass in their waste (1200g per week). This reduced so that the ones who recycled both cans and glass more often than monthly, had the lowest amount in their waste. The median figure for these most avid recyclers was only about 25% of that for the least active recyclers. All things being equal, this might imply that active participation in recycling reduced the quantity of recyclable wastes remaining in dustbin residues by up to 75%. It is equally noteworthy to highlight the fact that the most active recyclers as reported in the questionnaire, still generated a significant proportion of recyclable packaging waste in their disposal stream.

The example of metal cans was used to test this approach more specifically by comparison of the quantity of cans measured in the refuse compared with the reported use of can recycling.

Figure 7.11 Do people who recycle cans throw less recyclable metal packaging waste away?



Frequency of recycling cans

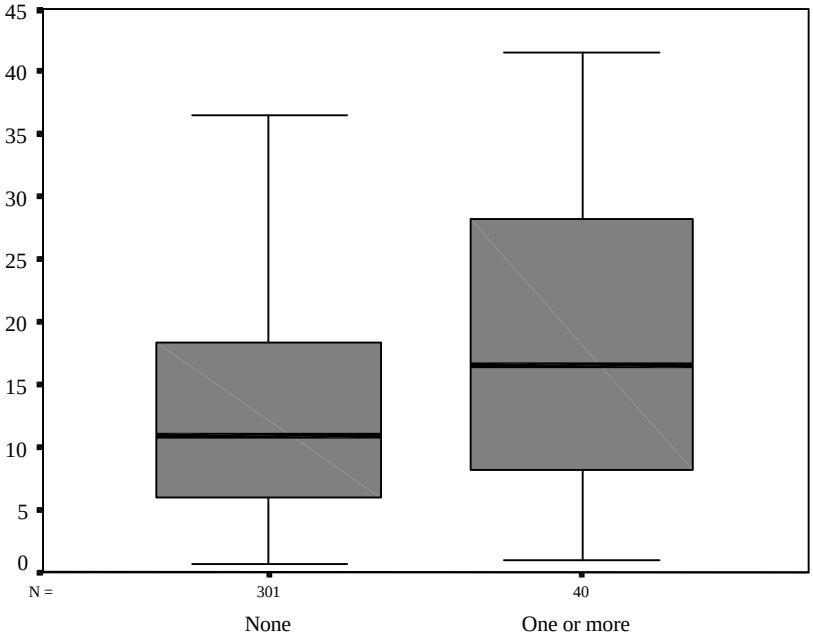
Respondents who recycled cans more often, were found to throw away less metal packaging waste than respondents who recycled cans less often (**Figure 7.11**). Those respondents who recycled cans fortnightly or more produced on average 0.4kg of metal packaging waste compared with 0.6kg for the less frequent recyclers, i.e. a reduction of a third in the amount of metal can packaging thrown away in their residual dustbin waste.

Finally, some analyses were run looking at the effect of various socio-demographic variables in the wastes found in the measured waste stream.

Do households with young families produce more kitchen or putrescible waste (non-packaging waste) than average?

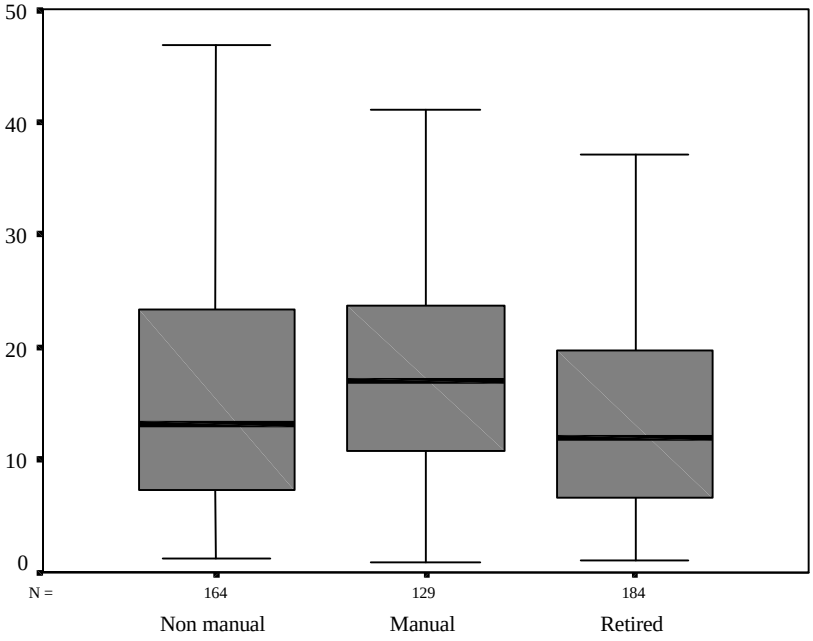
Households containing one or two children up to the age of four produced a larger amount of non-packaging waste and a higher median amount of such waste than households that contained no children of this age range. This may reflect the larger amount of kitchen waste and disposable nappies produced in these households because of them containing younger children. However, households with young children are likely to produce more waste per household because of the direct relationship between presence of children and household size: these factors are 'inter-correlated'. This example of inter-correlation' is discussed in more detail at the end of Section 7.

Figure 7.12 Do households with young families produce more kitchen or putrescible waste (non-packaging waste) than average?



Bearing this caveat in mind, it was found that the difference between these categories and the amount of waste produced was significant at the 95% confidence interval, with 14.2kg of non-packaging waste produced in households without children aged 0-4 and 19.5kg in households with 1 or more.

Figure 7.13 Does the total amount of waste produced vary according to the social economic group of the respondent?



Respondents in the manual socio-economic group produced both the largest amount of total waste and the highest median amount of waste (average 20.2kg a week). This may reflect tendencies identified from the questionnaire responses, for example for a higher proportion of non-manual respondents to recycle cans than those in the manual socio economic group.

Respondents who were retired produced the smallest median amount of total waste (average 14.9kg), reflecting the smaller household size and tendency to undertake lower levels of consumer spending amongst this group, as well as possibly the interest of this sub group in recycling and composting.

Inter-correlation amongst explanatory variables

The cross-analysis of variables describing behaviour and household characteristics with weight data from the compositional analysis has revealed a number of factors that influence the quantities of packaging and non-packaging wastes. However, many of these factors are found to be correlated with one-another (inter-correlated), thus making it more difficult to explain variations in terms of causative factors. For example, pet ownership was identified in the regression analysis in Section 4 being significantly positively correlated with total packaging waste, yet was itself positively correlated with household size. Similarly, a positive correlation between the presence of younger children between 0 to 4 years of age and total non-packaging waste was reported. As households with younger children are likely to contain more members than those without, this factor was inter-correlated with household size. It is therefore not possible to claim that households with young children produce more packaging waste, unless the analysis is disentangled from the household size effect. In this particular example, when mean quantities of packaging waste were compared for households of different size, those with younger children containing 3 or 4 persons in total produced significantly more non-packaging waste than those without younger children. It can therefore be concluded that presence of younger children was associated with larger quantities of non-packaging waste. One obvious factor would be the use of disposable nappies in such households.

Tables 7.10 and **7.11** contain simplified correlation matrices for some of the main variables used in the combined analysis of questionnaire and compositional data. The first examines correlations with total packaging waste per household, the second non-packaging waste.

Table 7.10 Correlation matrix: packaging waste per household

Correlations	Total kg/hhld packaging waste	Wheeled bin or not	Size of household	Pet owners	Professional /managerial	Children 0-4
Total kg/hhld packaging waste		0.1 **	0.4 **	0.2 **	0.1 **	
Wheeled bin or not						
Size of household				0.2 **	0.4 **	0.4 **
Pet owners						
Professional /managerial						0.1 **
Children 0-4						

** Correlation is significant at the 0.01 level (2-tailed).

Table 7.11 Correlation matrix: non-packaging waste per household

Correlations	Total kg/hhld Non-packaging	Wheeled bin or not	Size of household	Pet owners	Professional /managerial	Children 0-4
Total kg/hhld Non-packaging waste		0.3 **	0.1 **			0.1 **
Wheeled bin or not						
Size of household				0.2 **	0.4 **	0.4 **
Pet owners						
Professional /managerial						0.1 **
Children 0-4						

** Correlation is significant at the 0.01 level (2-tailed).

7.5 Summary

The analyses presented in this section have provided an illustrative study of the benefit to be gained from investigating waste at the level of the individual household.

- The highly problematic operational task of collecting waste and surveying households by post has nevertheless produced matched data for more than half the households in the original sample.

- The task of database matching has been successfully undertaken in order to produce a composite data set for statistical analysis.

- The statistical analysis undertaken through the SPSS pc software has produced results that illustrate the potential for developing a substantial and hitherto unexplored insight into the effects of household socio-demographic structure, consumer and recycling behaviour on the waste entering the municipal collected waste stream.

- To advance our understanding of ways of influencing the generation and recovery of used packaging and other elements in the waste stream such as the organic fraction, research of this sort needs to be developed with sufficient resource and over such a period of time as to allow for the difficulties encountered in this exploratory study to be anticipated and overcome.

8. CONCLUSIONS

Household waste is inherently varied in its composition and highly variable in most parameters used to quantify its characteristics. This study has focused on quantities of packaging and non-packaging waste discarded by householders for collection by refuse vehicles. Variability in weight data was found to be high in accordance with other household-based studies where the unit of analysis was a single sample of a week's refuse (Parfitt, Flowerdew, Pocock 1999:128). Despite this, results from the study have revealed relationships between household characteristics and variations in type and quantities arising. Such relationships cannot be readily explored when a bulk sampling technique is used (i.e. when waste from an individual collection round is analysed as a single aggregated sample), such as the method used previously for the National Household Waste Analysis Project.

The main relationships determined were:

- Significantly greater quantities of non-packaging waste were collected from wheeled bin households compared with those served by other methods of waste containment and these differences were greater than those observed between different social classes.

- Total quantities of packaging waste discarded were highly positively correlated with household size, with the exception of wood packaging, which was encountered in too few households to observe any trend.

- There was no significant difference between the proportion of total packaging accounted for by the five main materials when wheeled bin and non-wheeled bin households were compared.

- The combined effect of household size, method of containment and social class was found to produce significant differences in mean quantities of packaging materials discarded with 'professional/managerial' groups in wheeled bin households discarding significantly more metal cans, dense plastic and plastic film packaging than their counterparts in households with other methods of waste containment.

- A number of other household characteristics were found to be associated with particular elements in the waste stream, for example:

    - Presence of children and total non-packaging waste (after disentangling the household size effect)
    - Pet ownership and metal packaging
    - Frequency of cooking pre-packed meals and quantity of plastic packaging waste

- Many of these relationships were not surprising in themselves and similar findings have been established by previous regional research (MEL 1994). However, it was

important to prove such links between behavioural factors and variations in dustbin waste in order to establish an appropriate method of weighting the data to produce national estimates. Household size and method of waste containment were the two factors that explained most variation in the packaging content of collection round waste. As these are known from national data sources to be inter-correlated, it was decided to weight the sample to the national proportion of wheeled bin / non-wheeled bin households. This had the effect of simultaneously controlling for household size in that the weighted data had a mean household size close to the national average.

- The national estimate for total packaging waste, based on the weighted data, was 3.7 million tonnes of collection round waste (about 20% of the total).

- In addition, it was estimated that in total 450,000 tonnes of packaging waste from household sources in the UK was sent for recycling in 1997/98 ~ equivalent to a recycling rate of 11% of the packaging content of collection round waste.

- The combined total of packaging waste in the dustbin and that sent for recycling was therefore 4.15 million tonnes.

- Comparisons with the National Household Waste Analysis Project established that the packaging proportion of total collection round waste is subject to seasonal variation, particularly if wheeled bins are provided as the method of waste containment. As the waste samples for the Agency study were largely taken in April and May when there is a seasonal peak in non-packaging wastes, it was concluded that 20% packaging waste proportion was likely to be an under estimate.

- The best estimate, allowing for an element of seasonal adjustment, was 4.5 million tonnes of packaging waste or 23% of UK collection round waste, including the estimate for recycling.

- Future compositional studies of household waste will need to take more account of seasonal variation and include other outlets for household waste such as civic amenity sites. Separate measurement of quantities of materials collected by kerbside schemes would also improve the validity of the research design.

TECHNICAL ANNEXES

A1 AREA SAMPLING & STREET BLOCK SELECTION

The strategy adopted for sampling purposes was based on Enumeration Districts, the smallest set of geographical zones for which census data were available. A sampling strategy was designed by the North West Regional Research Laboratory, Lancaster University. The intention was to devise a method of collecting household-level data on the amount and composition of household waste in order to optimise the reliability of predictive models derived therefrom. In particular, the method was intended to be representative of the range of values of potentially relevant explanatory variables, and to allow models to separate the effects of correlated variables.

Previous analyses of the correlates of household waste generation have been inconclusive, in part because it was difficult to choose between different regression models based on different sets of explanatory variables. To reduce this problem, it seems worthwhile to select the sample to represent a wide range of conditions on most or all of the potentially relevant variables, and to minimise the extent to which these variables are correlated.

The following 25 variables may all be suggested to have some relationship to generation of total household waste or of some part of the packaging component of household waste, on the basis either of common sense or previous analysis.

Bin type*	Recycling rate*
Bulky waste pickup*	Civic Amenity site provision*
Population density	Household size
Unemployment	Population under 5
Population aged 5-15	Population aged 16-24
Retired people	Households with 4 or more children
Under 15	
Students	Households with 2 economically active
Adults	
Asians	Afro-Caribbeans
Employed women	Professional and managerial workers
Agricultural workers	People walking to work
Terraced housing	People taking public transport to work
Furnished rented housing	No bath
Central heating	

* Local Authority whole management variable

Apart from the first six, all of these were used in percentage form by dividing the counts by a relevant denominator (e.g. total population or total households) and multiplying by 100.

Because census data are not available at the street block level, data were used at the Enumeration District (ED) level. The target number of EDs was 60 but, for

operational reasons, it was decided to select 20 sets of three EDs, each set being grouped so that waste from all three could be collected on the same day. It was also arranged that Scotland, Wales and Northern Ireland should all be represented, and that there should be some regional spread within England.

In order to provide coherent sets of three EDs, sampling had to be done in two stages. First, 20 'primary EDs' had to be selected for the UK from the approximately 117,000 that exist. Second, further 'secondary EDs' had to be selected close to each primary EDs.

Twenty primary EDs were selected randomly; for each one, two other EDs were selected randomly from those within the same local authority. The whole set was then evaluated according to how representative it was of the range of values for each variable. A score was assigned based on three criteria.

First, the difference was calculated between the mean of each variable in the sample and over the whole country. A good sample would be one where these means are approximately the same. Second, the difference was calculated between the standard deviation of each variable in the sample and over the whole country. Again, a good sample would be one where the range of values nationally was represented as closely as possible in the sample. Third, the maximum correlation between any pair of variables in the sample was calculated. If two or more variables are highly correlated, it will be harder for the analyst to detect which of the two is more closely related to the generation of packaging waste.

If the twenty primary EDs did not include at least one each from Scotland, Wales and Northern Ireland, the sample was rejected. If it did, the score was calculated as described above, a low score representing an effective sample. One hundred samples were drawn, and the sample with the lowest score was chosen.

The EDs selected for Northern Ireland were used in a separate study conducted by Aspinwalls.

Logistical considerations

It would have been impractical to sample secondary EDs if waste was put out for refuse collection vehicles on a different day to that for the primary ED. Where this was anticipated in advance, it was possible to substitute another ED that matched the profile of the one originally selected as closely as possible across the 25 variables. However, the time and budget constraints meant that this was not always possible to achieve, and hence the sample eventually collected was smaller and probably less representative than would have been the case had it been possible to keep to the original sample.

Arranging visits to local authorities

Once the sample of twenty primary EDs and forty secondary EDs had been identified the relevant waste collection authorities (WCAs) were contacted to obtain an 'in principle' agreement to take part in the study.

Each WCA containing the primary and secondary EDS was then sent a formal letter stating the purpose of the work and including a ‘faxback’ form requesting operational details of the collection for each ED. Most WCAs were not able to identify the ED without reference to the identity of the electoral ward and so this was also supplied in the formal letter of invitation. For each ED, WCAs were asked to supply:

- Form of collection (e.g. weekly, fortnightly, refuse and recyclables)
- Method of containment (e.g. wheeled bin, sacks or paladins)
- Depot and site manager, (name, address and contact details for depot manager for the round)
- Day and time for collection
- Any other special collection arrangements (e.g. separate kerbside collection for some recyclables).

Selection of 'street block' sampling points

Ideally, each of the three EDs in each location was to be used as a sampling point from which household waste should be collected from a 'street-block' consisting of around 40-50 properties within the designated ED. In practice, it was found that this sampling methodology was over-ambitious within the constraints of time and resources, and that it was not possible to use many of the secondary locations selected through the sampling protocol detailed above, because:

- The collections did not fall on the same day, so in order to collect waste from householders from separate EDs, it would have been necessary to visit the location on several days;
- There was insufficient time to collect the waste and also travel to and from the location, ensuring waste was delivered on time at the sorting site to be sorted the next day.

It might have been possible to adhere to the sampling regime more rigorously with a longer lead time allowing more detailed planning, and a larger selection of sampling days.

On the day of collection, practical decisions had to be made by the field survey team in conjunction with the RCV collection crew. This involved deciding 'on the ground' precisely which houses formed the individual street blocks of 40-50. This was usually on simple local features such as from road junctions up to, say, alleyways or shops which formed obvious visible delineation of the 'block'. The need for a simple and practical designation evident both to field survey team and RCV crew stemmed from the need to ensure that no property had a 'missed collection'. The practical constraints meant it was not always possible to keep absolutely precisely to the ED boundaries, but the key requirement was to ensure that property types were kept similar to those within the specified ED.

A2 HOUSEHOLD WASTE SAMPLE COLLECTION

A2.1 Pre project investigations

The methodology for sampling and analysis of household waste was based on the output from two workshops involving all contractors in the consortium to determine specific operational protocols, followed by pilot trials undertaken in Luton and Birmingham. The pilot trials had two components: to explore the practicalities of sampling, and to test the practicability of sorting and waste classification.

Pilot sampling campaign

A pilot sampling campaign was carried out on 12 March 1996 in the Castle Bromwich and Moseley areas of Birmingham, with the objective of discovering how best to intercept householders' waste in advance of the Refuse Collection Vehicles (RCVs). It was also used to gain knowledge of how many sacks of waste might realistically be intercepted by a collection team.

A 7.5 tonne box van was hired, and arrangements made with the City Council to collect householders' refuse from a street on a round in an area agreed in advance. It was found that it was feasible to collect waste arising from approximately 40 households in 1.25 hours, identify the households concerned, tagging the sacks and loading the waste into the van. The trial involved the use of two personnel, a driver/loader and 'mate'.

Pilot analytical campaign

A pilot analytical campaign was run at a depot in Luton to evaluate the effectiveness of the protocols established in a preliminary workshop. In particular, the ramifications of analysing a bulked sample as compared to sorting waste kept separately from individual households were investigated.

For the bulk analysis trial sort, waste arising from 40 households, amounting to approximately 0.5 tonne, was tipped onto the sorting room floor. This was then coned, quartered and sorted by two operatives. Waste from the sample was placed onto a sorting screen fitted with 10mm apertures, and the different types of components in terms of packaging and non-packaging materials were categorised. In the afternoon, analysis of waste from single households was carried out in the same way but individually for each household rather than by bulking.

In general, it was found that analysis of a bulk sample was more time consuming and difficult than analysing waste contained in separate sacks. It took approximately 45 minutes to sort a proportion of the coned and quartered bulk refuse sample, representing waste from approximately 10 households. Sorting of the remnants of the bulked sample was particularly difficult. In addition, the waste could not be related to individual houses, and the sub sampling was difficult to carry out without the assistance of mechanical equipment. In comparison, it was found that a team of three, (one supervisor and two sorters), took 1 hour to sort 4 households' waste into primary categories, and a fifth household’s waste into both primary and secondary categories, providing sufficient detail for subsequent comparison of data at the household level.

Another trial was run in Birmingham using the waste collected on the trial collection round. At this stage, final protocols were decided upon, and the methods for primary and secondary sorting agreed.The second pilot exercise involved the sorting supervisors recruited for the project. In both sorting trials, times were noted for typical sorting rates per bag. Under timed conditions, it was found that one primary sample using two operatives could be sorted to the primary-level categories in 15 minutes (i.e. 4 household primary sorts). The secondary-level, more detailed sort took two sorters a further 30 minutes, giving 45 minutes in total to sort the waste from 5 households in this way.

Important lessons learned from the trial collection and sorting exercises

1. Contacting the council was an important factor in preparation for the sampling exercises. In order to avoid any potential misunderstandings with the refuse collection crew, it was found best to agree in advance on the street block to be sampled. In most cases during the actual exercise, the operatives were able to arrive at the allotted street on time, however, if the RCV crew did arrive in advance of the collection team, it was agreed that the team would, if possible liase directly with the collection crew on the ground and find an alternative street-block of 40-50 households reflecting a similar type of neighbourhood to the original selected street.

2. Ongoing liaison with the council refuse collection crew directly, on the day of the pick-up was often impossible. If any hitches arose, for example, if delays were encountered on the journey to the collection site, it was imperative that details were provided for a named contact at the council, who could often liase with the collection crew through radio contact. For this reason, it was important for the field survey operatives to have a reliable mobile phone or radio contact.

3. It was important that advance preparations were made every evening prior to the collection to ensure the field survey operatives had the following items of equipment available and in sound working order. Other equipment could be left in the van overnight if parked in a secure location. The checklist was used as a QA procedure by the field sampling supervisor every night/morning prior to departure.

<u>Materials prepared every evening in advance of the pick-up by the collection team supervisor</u>

1. Sufficient numbered labels for the sacks used to collect the refuse

2. Map, (and where appropriate, ‘Routemaster’ - computer generated directions) to specified destination

3. Sufficient sacks to collect refuse. A minimum of 80 were taken every day, to allow for any multiple-bag households or split sacks.

4. Signed letter of authorisation to provide details to any householders of the background to the study and the reason for the change in collection crew on that day.

5. Fully charged mobile phone. Recharged every night, overnight.

6. Collection sheets to link bag reference with address.

7. General area description sheet. To record descriptions of weather conditions, street sketch and other general comments.

Materials/ equipment left in the van overnight

1. Gaiters

2. Road Atlas

3. Gloves for the collectors

4. First-aid kit

5. Luminous vests

6. Spare pens and paper

Collection crew supervision

Undertake final check prior to setting off of all equipment

Map-reading during travel to the site.

Liaison with project manager and council officer to inform of progress

Identification of street-block

Issuing cash for provision of agreed essentials

Tasks undertaken by the project manager every day

Ensure mobile-phone batteries fully-charged

Be available as a back-up driver if a new or less reliable driver does not arrive at allocated time

Ensure sufficient cash-float available for staff

Issue cash in morning for diesel, food, against approved expenditure amount.

Countersign cash-float sheets

Requisition cash-float internally

General duties of Sorting-site supervisor

Instruction/decisions re determination of waste sorting categories

Quality check of all data sheets

Detailed secondary-level sorting and supervision

Resolve any internal staff problems, e.g. low work-rates, staff not appearing,

Ensure site Health and Safety instructions abided by.

General duties of a project manager

Check insurance cover for sites/collection crew/van-hire

Ensure a valid Waste Carriers Licence was held by the operating agency

Arrange van-hire and pick-up, usually over the weekend to ensure available for first pick-up on a Monday morning

Arrange payment for van-hire (cash deposit and daily charge). Requisition cash internally and pay at van-rental company in advance.

Recruit driver using temp agency

Recruit (student) collection crew

Recruit refuse analyst teams

Liaison with van-hire and temp agency companies to ensure named drivers are suitable and qualified to drive vans

Arranging licence details of (multiple) drivers to be forwarded to van-hire company.

Arranging (multiple) driver visits to van rental offices to ensure fit and appropriate person to drive van.

Recruit additional staff at short notice if refuse analysis team operatives drop out.

Resolve any personnel conflicts arising, e.g. low work-rates

Provision of refreshments for sorting site staff

Workshops

Workshops were held incorporating all contractors and the client nominated officer on the 26 February 1996, 7 March, 1996 and 13 March 1996 to assist in evaluating the results from the pilot studies and ensure an appropriate protocol was agreed.

A2.2 Waste collection

Waste collection for the full field survey programme was undertaken by two parallel operations, based at M.E.L Research in Birmingham and Luton University in Luton. Each operation was set up with the following resources:

Collection team: 1-2 drivers
1 operative to assist with collection

Equipment 1 7.5 tonne truck
Numbered plastic wheely-bin liners:

Dimensions 24"x46"x54"
Gauge: 140

Collection sheets
Liaison details for the contact and authority being visited
1 mobile phone per team
1 map
electrical insulation tape

PPE: Gloves, gaiters, overalls, luminous vests,

General approach

Fieldwork was undertaken using operatives from both the Luton and Birmingham sites. Each of the local authorities in the survey was allocated in advance to either the Luton or Birmingham team. Broadly, Luton covered southern and southwest England and Wales, Birmingham the midlands north to Scotland. The Northern Ireland site was undertaken separately by Aspinwall & Co with supervisory staff from M.E.L Research.

Each site was supplied with waste delivered by their respective collection teams. The collection team consisted of either one or two drivers, along with an operative to assist with collection of the waste from householders. The additional driver would double up as an operative on each day, particularly where long journeys were involved.

Preparations in advance of the study included purchase of appropriate sized wheely-bin liners for the purpose of decanting household waste, (either sacks or loose waste). Liners were numbered consecutively using computer mailshot labels.

On each journey, a team would be provided with the details for the rendezvous at a pre-arranged time and venue, usually a council depot. Owing to the early start of many collection rounds, the team would have to leave the base early in the morning to make sure rendezvous took place before the collection round started. Because fieldwork was happening every day, with waste conveyed back daily to the sorting sites, there was no opportunity for crews to stay overnight in advance of collection. On a longer time-scale this might have been feasible and would have considerably eased the pressure on the teams and the risks of traffic delay jeopardising a whole day's sampling. In the event this did not occur but the risk is high.

The box-van had to be loaded in advance of the following day's collection visit, using the checklist and QA procedure described earlier. The van contained sufficient numbered wheely-bin liners, appropriate PPE, maps, details and contacts for the rendezvous.

Upon arrival at the local authority, the team were usually taken to a pre-arranged street block or group of street blocks by the depot or collection round supervisor.

The collection team was provided in advance with directions for the meeting point, a named contact and telephone details in the event of the problem occurring with the liaison process. This was arranged through the preliminary faxback and telephone communications described earlier.

In the event of a delay, or problems with finding the meeting point, the team could contact the local authority officer responsible for the area and locate the meeting point on the morning.

Collection of waste contained in plastic sack

1. The team identified the assigned street block and determined the specific designation of properties to be incorporated in the 'street block' as discussed earlier. Next the van's tailgate was slightly lowered to enable operatives to gain access to the rear of the van during collection. Where possible, sacks and additional loose waste from each household were identified, and each householder's waste placed into a numbered sack. Sacks were numbered by local ED code and a successive sack number.

2. The sacks into which the household waste was placed were then sealed to ensure sample integrity during transportation to the sorting base.

3. The supervisor of the collection team noted details on a form, detailing the sack number and the associated house and street name on the collection sheet provided (see appendix). Note that there may be several sacks for each house. Also loose items were placed in numbered sacks and allocated to the house of

arising. Supervisors were also instructed to record houses where no waste appeared to have been set out for collection.

4 In those areas where waste had been removed from households and placed in the street before the arrival of the collection team, the sacks were identified as belonging to a group of houses, and the details noted on the collection sheet of the range of houses from which the waste was most likely to have arisen. This practical constraint is important in its subsequent impact on the scope of the statistical analysis in the project. While it does not prevent the aggregate analysis of waste arising from each street block, it does however cut down the number of households where it is possible to link the individual household's arisings with the results of the subsequent postal questionnaire survey.

5. The sacks were then taken to the box van, by holding the neck of the sack and loaded using the powered tailgate.

6. The driver moved the van along in parallel with the two operatives collecting the waste.

Procedures for collection of wheeled bin waste

Field survey collection operatives adopted a slightly different approach for premises subject to wheeled bin collection, as the householder often deposited the contents loose within the receptacle.

1. The two operatives tipped the contents of the wheeled bin into a numbered plastic sack. In some cases, more than one sack was used where the bin was very full, due to the inclusion, for example, of large quantities of garden waste.

2. The sacks into which the household waste was placed were taped using electrical insulation tape to seal the sack during transportation.

3. The sacks were loaded into the box van and a collection sheet completed as before.

In both cases, once the waste had been collected, the team returned with the waste to the depot/sorting site. There the waste was unloaded and the tagged, sealed bags placed in numerical order in advance of the sort. At this stage, those householders' bags were identified for the secondary sort and were separated from the main batch of collected waste on which primary sorting was to be carried out.

A2.3 Recruitment of staff

Supervisors in Luton were recruited from the Centre for Waste Management: Students on the MSc in Waste Management course were the core operatives.

In Birmingham, supervisors were recruited from the University of Central England MA course in Environmental Management. Remaining operatives were recruited from Temporary Employment Agencies.

A professional driver was used in Birmingham on the collection rounds, along with two operatives. In Luton a professional driver also was recruited, with two operatives, one of whom could assist with driving on long journeys.

A2.4 Recommendations for future projects - refuse collection and sampling

Although the project was completed for the most part successfully, several commitments were entered into at an early stage that would have been adapted with the benefit of hindsight:

The ***gauge of the sacks (140) was not thick enough*** to bear the contents of household refuse containing shards of glass; or that were particularly heavy. In future it would be recommended that the collection crew be provided with a thicker gauge of sack or a supply of available sacks to cope with difficult loads.

A ***7.5 tonne truck should not be used***. These proved to be unnecessarily large; 3.5 tonne trucks are large enough for fieldwork of this sort. The most important specification of the trucks, once large enough, is that they have a powered tail-lift. One driver commented that larger, (elevated roof) transit vans are now available with powered tail-lifts. These should have sufficient capacity, and would prove more economical in diesel consumption. A potential drawback however is that odours from the refuse may pass directly into the cabin. This type of van should however be tried.

A ***fuel card*** would eliminate the need for a cash float for daily diesel purchases. This should be considered in any similar fieldwork in the future.

It was found that the ***selection of the driver*** was critical. In some instances, the temporary driver did not arrive on the allotted date/time. By picking a responsible driver, it avoids the need to provide a replacement at what could be very short-notice using other staff on the project. Where possible, the driver should be a nominated supervisor. The early starts in the morning meant that the driver has to be reliable, mature and trustworthy. In addition, the driver has to be over 25 and have no serious offences on his/her driving licence to meet the insurance requirements of the van hire company.

In general, the supervisor selected should be responsible and mature. With the provision of a cash float, opportunities exist for unauthorised expenditure. Good selection procedures help to avoid such matters arising.

A3 THE SORTING OPERATION

A3.1 Introduction

This section describes the equipment and processes used in sorting the waste samples into primary and secondary levels.

Common equipment

- Sets of scales
- 1 mobile phone
- Plastic bin-liners for storage of plastics

Primary sort

- Team of individuals per table, consisting of two operatives and 1 supervisor
- Sorting table
- Weighing containers for packaging fractions
- Magnet to identify ferrous and non-ferrous metals
- Data sheets and clipboard for the recording of each bag's details

Secondary sort

- Additional containers
- Fine calibration scales

A3.2 The procedure for primary sorting

1. The supervisor identified the tag number on the bag to be sorted.

2. The sorting supervisor weighed the total amount of material in the sack and recorded the net weight and identification number on a form.

3. The bag was opened using scissors on the neck of the bag and the mixture was then tipped onto the sorting table. It was found that it was easier to tip the sample onto a sorting table, rather than using a sorting screen. This allowed adequate access to the sample, easy access to the packaging and residual quantities could be swept off of the table and placed in a container for weighing.

4. The sorters then split the sample into the seven categories for the primary sort: these were the six designated packaging categories and the seventh aggregate non-packaging category. The operational process involved first removing all items of non-packaging material; placing the material in one separate pre-weighed container. All items identified as packaging were then sorted into each of the six main primary packaging categories, by placing them into separate pre-weighed containers:

- Paper and card
- Dense plastic

- Plastic film
- Glass
- Metals
- Wood and any unclassified packaging

5. Each separate fraction (the six packaging categories and the residual non-packaging category) was then weighed together with the container into which it had been separated, the actual weight of the primary waste category being calculated by deducting the default 'tare' value for the containers of 900g.

6. The sorting supervisor then carried out a data quality check, to see that the weights for the overall initial weight of the waste were approximately equal to the weight of the sum of the individual fractions. If the weights differed, then the form was rejected, and the fractions re-weighed. In the event of discrepancy the weighed fractions were taken as the definitive measurement so it was important that no waste was lost in this sorting process.

7. Plastic packaging waste was segregated at this stage into plastic bin-liners for further sorting into plastic type at a later stage.

8. Once the data had been QA-approved with the supervisor, the waste from the containers was then emptied directly into the skips provided at the site for disposal.

A3.3 Procedures for the secondary sort

The procedure was identical to the above to produce a seven-fold classification into the primary categories, then for each primary category, the waste was re-sorted into its secondary components, e.g. paper packaging was sorted into the secondary categories for each paper material type, by placing in a separate container. Secondary sorting was undertaken for both the packaging and non-packaging primary fractions.

Paper and card packaging:

- Paper packaging
- Corrugated card
- Non-corrugated card (non-grey)
- Non-corrugated card (grey)
- Other paper and card packaging

Plastic film packaging:

- Film wrapping
- Metallised film
- Other plastic film packaging

Dense plastic packaging

- Bottles

- Expanded blown plastic
- Other dense plastic packaging

Glass packaging

- Clear containers
- Brown containers
- Green containers
- Other glass packaging

Metal packaging

- Ferrous beverage cans
- Ferrous food cans
- Ferrous aerosol cans
- Ferrous closures
- Other ferrous packaging
- Non-ferrous beverage cans
- Non-ferrous food cans
- Foil containers
- Non-ferrous closures
- Other non-ferrous closures

Wood and miscellaneous packaging

- Wood packaging
- Miscellaneous

Non-packaging residue

- Paper and card non-packaging
- Glass non-packaging
- Plastic film non-packaging
- Dense plastic non-packaging
- Textiles non-packaging
- Ferrous metal non-packaging
- Non-ferrous metal non-packaging
- Putrescibles
- Miscellaneous combustibles
- Miscellaneous non-combustibles
- <10 mm fines
- Packaging inclusions and exclusions

For some items it was difficult to determine whether they should be counted as packaging or non-packaging. Guidance was therefore produced in the form of a table to assist in defining whether material was packaging or non-packaging, as outlined below: (Categories were defined in close consultation with the other contractors and INCPEN during the Agency workshops).

Inclusions (packaging)	Exclusions (non packaging)
Plastic film from delicatessens used to wrap food	Paper and plastic carrier bags
Prescription medicine bottles	Wrapping paper
Cardboard boxes	Cardboard cylinders from toilet paper
Paper, polystyrene chips etc. used to protect goods in transit	Direct mail envelopes
Paper bags and wrapping paper	
Paper used to wrap bacon, fish and chips	
Milk and juice cartons, Tetrapak	
Food trays, MacDonald shells and cups	
Chocolate bar foil	
Kitchen foil	
Plastic laminates on paper e.g. dog biscuit bags	
Mushroom cartons - (cardboard and metal handle)	

A3.4 Site procedures at the completion of a day's sort

Cleaning of the sorting tables

At the completion of a day's sorting, a thorough clear up was carried out as an important health and safety measure. Under the instructions of the supervisor, tables were cleaned with bactericidal cleaner. Bactericidal concentrate was added to a bucket of water, and rags used to wipe the surfaces thoroughly.

Cleaning of the sorting containers

In addition to cleaning the tables every day, the reusable plastic weighing containers were washed out regularly, or when a particular accumulation of dirt accrued on the inside of the box. The same diluted bactericidal cleaner as stated above was used.

After the cleaning of the tables and the boxes, the sorting area was swept to avoid any accumulation of waste that could attract vermin.

A3.5 Logistical considerations

Collection visits had to start early in the morning. In order to stand any chance of arriving before the usual collection crew, the journey often had to start at 4.00 - 4.30am every morning. Staff therefore had to wake up at 3.00am in some cases, and in other cases, some individuals had to arrange complicated travel arrangements or arrange to be picked up by a collection van on its way to the collection site. For future projects, consideration should be given to staff locations in relation to the collection base and the option of planning and resourcing the work to allow staff to travel the day before

and stay overnight. It is unreasonable to expect employees to be capable and willing to get to the collection base at times of around, (and preceding) 4.00am every day for a sustained period of a fortnight.

It was often a complicated process to ensure journeys fell within the driver's tachometer hour allowance. This was another drawback of the use of 7.5 tonne trucks, which require the tachometer regulations to be followed. However, in general, a consideration for future studies should take into account the amount of hours the driver spends driving; and if possible, on longer runs, to provide back-up driving capability from within the collection team. The back-up driver would, however need to be registered with the rental company, and fall within the person specification outlined above for age, responsibility and no serious driving penalties.

It was important that more time (or a separate team) be allocated to the particularly long runs, e.g. Aberdeen and Cornwall. For the Aberdeen collection, it was possible within the timeframe to travel to the collection site on the day prior to the collection, stay overnight and make the pick-up on the subsequent morning. Travel back was then feasible within driver's tachometer allowance.

The selection of a ***local van-hire company*** is important. The requirement to move vans between centres at the start and finish of the project proved to be an additional burden on staff time. Where possible, a van-hire company should be selected as close as possible to the sorting.

Other considerations

Provision of good refreshments, a radio and clean rest areas for the refuse sorters assist in making a difficult job more amenable.

A4 POSTAL QUESTIONNAIRE SURVEY

A4.1 Background

During the summer of 1997, all households falling within the street blocks whose waste had been collected in the spring 1996 survey were administered with a postal questionnaire survey. Survey design was carried out in close collaboration with the Agency, with a view to examining key socio-economic attributes, attitudes and behaviour of the households with the objective of examining links between the household and the waste generated. This was the first time such an exercise of this type had been attempted on a broadly nationally representative sample.

A4.2 Design

The postal questionnaire design was focussed on being short and straightforward for the householder to complete. Where appropriate, the householder was instructed to skip inappropriate questions.

The survey was drawn up using a matrix that links the questions as phrased, to the information that it supplies for analytical objectives. Questions are set broadly to obtain information on householder attributes, attitudes and behaviour:

Question (examples)	Attributes	Attitude	Behaviour
Type of bin	✓		
Ownership of garden	✓		
Newspapers received	✓		
Frequency of recycling			✓
Reasons for not recycling		✓	
Visits to CA sites			✓
Frequency of composting			✓

Additional input was sought from DETR to supplement the national composting survey being carried out at the time, and these views incorporated in the design of that section of the survey.

A preliminary section on the front of the questionnaire provided detailed information and instructions on how to complete the survey booklet.

A4.3 Questionnaire administration

Mailing

A cleansed dataset was obtained of the addresses collected during the waste collection phase of the study.

Postcodes were obtained and entered on the address database through the national postcode service provided by Royal Mail

A covering letter was drafted, and signed by the lead Environment Agency official

The final agreed version of the questionnaire survey form was printed to provide sufficient copies for all householders. In estimating numbers, an allowance was made for sending a reminder copy and the print run was therefore 1.6 times the sample size.

A tagging system was then set up. This was operated by consecutively numbering the address file dataset from 0-1700.

The self-sticking address labels were then run off using a mail-merge programme, with a note of the tagging number in the corner. Envelopes were labelled with these labels.

A prepaid freepost return set of envelopes was printed, again allowing for reminders.

The envelopes were then stuffed as follows:

1. A copy of the questionnaire with the tag number printed on the back using a consecutive numerical stamper.

The tag on the questionnaire was cross-referred with the envelope tag number to ensure that the householder received the appropriate tag to match their address to enable subsequent matching of waste composition and questionnaire data.

2. A freepost return envelope to allow the sender to return the questionnaire free of charge.

3. A copy of the Agency covering letter explaining the background to the survey and requested date to return for the questionnaire.

The first mailing took place on 28 July 1997. Returns were logged on a computerised tracking system. A second, follow-up mailshot was carried out on the 23 August 1997.

Information management and data entry

Two weeks after the first postage date, a follow-up reminder was sent to all non-responding households, with another copy of the questionnaire and freepost reply envelope, to help boost the final response rate.

The returned batch of questionnaires was examined by the survey manager, and standard qualitative responses placed within a standard questionnaire coding frame, for example, reasons provided by respondents for not recycling their waste.

Questionnaires were examined closely, and responses coded as appropriate by a survey quality researcher.

On completion of the postal stage of the survey, a data-entry form was set up in Microsoft Access to allow the postal survey returns to be entered into a database, incorporating the range of responses and codes used to enter the detailed longer, qualitative responses. This database could be linked by household reference number to the datafile containing the waste composition analysis records.

A data-entry clerk entered the survey returns into the database using the coded questionnaires received. The database was designed to incorporate the tagging number system to enable linking of the questionnaire and weight data at a later stage.

Data Cleansing

The questionnaire database was cleansed using a 10% random check of questionnaires and general eyeballing of data to identify any systematic data-entry errors. Access database programming ensured that invalid data values could not be entered.

A5 PACKAGING STUDY: VERIFICATION STUDY ON THE POLYMER COMPOSITION OF PACKAGING PLASTICS IN HOUSEHOLD WASTE

A5.1 Aim

To verify the polymer identity and fractional proportions of plastic packaging found in household waste (classified according to visual inspection previously in the study).

A5.2 Methodology

The plastics fraction of the waste sampled in the main survey was retained after handsorting, with a view to making a more detailed effort at categorising the individual polymer types. The polymer composition of household waste is important if recovery and recycling is envisaged. Mixed polymer plastics form a relatively low-grade material with few market outlets and little value in the recycling market. Polymer separation however allows a series of higher-grade streams to be produced and so long as cross-contamination is contained, there are better market prospects and higher value in the recycling market. MRF operations entail handsorting of the packaging fraction to create precisely these separate polymer specific streams.

The in-depth investigation of the plastics packaging fraction was undertaken in this study using firstly a replica of the MRF-style handsorting approach, and secondly a spectroscopic instrumental technique.

Firstly, all plastics packaging from the main survey was re-bulked. The retained bulked sample from the survey weighed about 0.4 tonne allowing for losses in the re-bulking. This sample was inspected and individual items categorised into their polymer types by Ray New and Richard Thomas during the summer of 1996. Seven categories were used, and individual items were placed into one of these categories based on industry labels on the product and the analysts' expert opinion.

1) Polycarbonate
2) HDPE
3) LDPE
4) Polypropylene
5) Polystyrene
6) PET
7) PVC

The first stage of the process involved laying out the retained sample onto the hall floor, then coning and quartering the sample twice. This gave a representative sub-sample of approximately 25-kg, which was then divided into the following product-based sub-samples:

- Bottles
- Food containers
- Film
- Other

Each individual item within these product-based sub-sets was then sorted into one of the seven polymer types using the information provided by the manufacturer using standard recycling identification markings. These were either the standard numeric identifiers (1-7), or initials identifying the type of plastic polymer.

Clues to polymer type can be obtained from various characteristics. Plastic film was extracted first, then all remaining dense plastic items were individually considered. Opaque materials were generally classified as HDPE, and if clear, either PVC or PET depending on the moulding process (a 'smile' seam indicating a PVC forming process and the presence of s 'screw plug' a PET extrusion forming process). Food trays were generally polystyrene and all lids or closures PVC. All the above considerations were applied unless if polymer type specifically stated on the container. Where containers consisted of multiple material elements (for example, PET bottles with HDPE tops) these were separated where physically practicable, as is done in MRF operations. Mixed inseparable items were allocated to their principal category.

The samples of types of plastic were then weighed using the scales on the site, measured in grams. Operationally, the sorting was done on a 'split-half' analysis method and the results of the two halves, together with an unweighted arithmetic average of the percentage assays of each half, are shown in the following Table.

Table A5.1 Compositional Assay of Polymer Fraction Household Waste Packaging

Plastic type	Sample 1 (wt. grams)	Sample 1 (% w/w)	Sample 2 (wt. grams)	Sample 2 (w/w)	Average (%w/w)
HDPE	1693	15.4%	2732	21.1%	18.2%
Polycarbonate	0	0%	41	3.2%	1.6%
PET	1862	16.9%	2041	15.7%	16.3%
Vinyl	776	7.0%	1017	7.8%	7.4%
Polyethylene	114	1.0%	768	5.9%	3.5%
Polyproylene	194	1.8%	76	0.6%	1.2%
ABS	7	0%	0	0%	0%
Plastic Film	4360	39.6%	3467	26.7%	33.1%
Polystyrene	1034	9.4%	1382	10.7%	10.1%
Unknown	982	8.9%	1440	11.1%	10.0%
Total	11022	100%	12964	100.0%	100.0%

The results of the two split half samples are relatively consistent. The biggest difference is in the plastic film category where results were heavily dependent on the presence or absence of large items such as refuse sacks and consumer product wrapping.

Sub-samples of each of the seven categories contained in three sacks were subsequently retained to enable spectroscopic verification to be carried out later. These sub-samples required prior removal of extraneous detritus from the item originating

either from the original product or cross-contamination from the general waste stream, in particular by the putrescible organic fraction. This process is colloquially termed ‘de-crudding’ and was undertaken by Johnsons Total Cleaning Maintenance, Birmingham using an industrial steam cleaning method at a total cost of £50.

A5.3 Analysis and verification

These sub-samples were analysed free of charge by Intex Logistics Ltd while demonstrating their portable plastics spectroscope at the ‘Recycling 96’ Exhibition at Stoneleigh in Warwickshire between 29 September and 1 October 1996.

The Spectrometer, produced by Intex Logistic Ltd in Southampton, works by swiping a bar-code pen reader over the plastics surface, and where identified, the plastic polymer type is stated within approximately 5 seconds.

A5.4 Results from the trial

Samples were taken to the exhibition where the reader was being demonstrated. The reader could not identify many of the various types of plastics in the sample, in particular, films and yoghurt cartons. It was considered that the material, and its physical condition, (slightly grubby despite steam cleaning, and not having a sufficiently hard surface), was not able to generate a `clean' spectrographic signal.

The trial of the pen reader was therefore considered unsuccessful. Analysis of the packaging fraction was therefore dependent wholly on the visual inspection techniques as outlined earlier.

A6 QUESTIONNAIRE

THE NATIONAL HOUSEHOLD WASTE SURVEY

HOW TO FILL IN THIS QUESTION BOOKLET

Thank you for filling in this Questionnaire. We believe you will find it easy and interesting, and it should only take a few minutes.

Please read each question carefully. Most questions can be answered by putting a tick ✓ in a box next to the answer you want to give. Sometimes you are asked to write your answer in a space under the question.

When you have finished one question, move to the next question, unless there is an instruction to jump ahead to a different question. Please keep a look-out for these instructions - and remember to follow them!

When you have finished, please post the questionnaire to us in the enclosed envelope. If you have lost the envelope we sent you, please use an ordinary envelope, and address it to:

The National Household Waste Survey
M.E.L Consumer Services
FREEPOST
Birmingham B7 4BR

Finally, you can be assured that your answers will be treated in strictest confidence and your name and address will not be known to anyone except the survey team.

A survey on behalf of the Environment Agency

The first question is about the use of your Council's refuse collection service

1a) How is your weekly household refuse collected? Tick ONE box only.

- ☐ Wheeled bin provided by the Council
- ☐ Metal dustbin provided by the Council
- ☐ Bin you have to provide yourself
- ☐ Sacks or plastic waste bins provided by the Council
  (if yes, how many sacks/bins do they give you? ……
- ☐ Sacks you have to provide yourself

1b) If you use sacks, how many do you actually use each week on average?

- ☐ One
- ☐ Two
- ☐ Three
- ☐ Four
- ☐ More than four. Please state the number of sacks used ……..

The next questions are about the Council's waste disposal sites

2 Do you know the Council have places or tips, where you can take your items of rubbish to be disposed of? (They sometimes call them 'Public Waste Disposal

☐ Yes

GO TO QUESTION 3

☐ No — **GO TO QUESTION 5**

3 On average, over the year as a whole, how often does your household use these sites? Tick one box.

- ☐ Monthly or more often
- ☐ Between once a month and once in 3 months
- ☐ Less often and 3 monthly
- ☐ Never — **GO TO QUESTION 5**

GO TO QUESTION 4

4 Which of the following types of waste do you generally take to the Council's waste disposal site? Complete boxes as required

- ☐ Garden waste
- ☐ DIY waste
- ☐ Waste for recycling
- ☐ Bulky household items, such as furniture, fridges etc.
- ☐ Other. Please give details ……..
  ……..

Now some question about recycling

Council recycling <u>collection</u> services

5 Your local Council may collect your recyclables, (eg glass, paper, plastic), specially from your doorstep in separate containers. If so, how often do you put the following items of waste out separately for the **Council's special recycling collections?** If your Council does not provide this service go directly to question 6

	Paper	**Glass**	**Cans**	**Clothing**	**Plastic bottles**
Weekly or more often	☐	☐	☐	☐	☐
Fortnightly	☐	☐	☐	☐	☐
Monthly	☐	☐	☐	☐	☐
Less often than monthly	☐	☐	☐	☐	☐
Never	☐	☐	☐	☐	☐
Council don't collect items	☐	☐	☐	☐	☐

Recycling centres

6 How often do you take the following items to a recycling centre, (including those at the Council's waste disposal site)? Please tick one box under each item.

	Paper	Glass	Cans	Clothing	Plastic bottles
Weekly or more often	☐	☐	☐	☐	☐
Fortnightly	☐	☐	☐	☐	☐
Monthly	☐	☐	☐	☐	☐
Less often than monthly	☐	☐	☐	☐	☐
Never	☐	☐	☐	☐	☐

NOW GO TO QUESTION 7- If you 'never' use recycling centres or bottle banks

Answer if you 'Never' use a recycling centre or bottle banks

7 What are your main reasons for not recycling waste at recycling centres or banks?

.....

.....

8 Is there anything that would make you recycle more than you do at the moment? Tick one box only.

☐ No

☐ Yes

If Yes, please say what .....

.....

The next questions are about the things that go to make up household waste

9 How many papers does your household get? (That's all together, thinking of everyone in the household).

Daily newspapers (bought)	☐ Two or more a day	Sunday newspapers (bought)
	☐ Two or more	
	☐ One a day	
	☐ One	
	☐ None	
	☐ None	
Free newspaper	☐ Two or more a week	
	☐ Two a week	
	☐ One a week	
	☐ None	
Magazines	☐ Two or more a week	
	☐ Two a week	
	☐ One a week	
	☐ None	

10 How often does you household cook the following types of food?

Pre-packed meals e.g. frozen

- ☐ Every day
- ☐ Once or twice a week
- ☐ Less than once a week
- ☐ Never

Tinned foods/tinned vegetables

- ☐ Every day
- ☐ Once or twice a week
- ☐ Less than once a week
- ☐ Never

Fresh vegetables (not tinned or frozen)

- ☐ Every day
- ☐ Once or twice a week
- ☐ Less than once a week
- ☐ Never

11 Where does your household do most of the household food shopping? Tick ONE box.

- ☐ Local corner shops
- ☐ Supermarket
- ☐ Large out-of-town hypermarket
- ☐ Other - please state where

……..

12 How many canned drinks are consumed in your household in an average day?

Cans of alcoholic drinks per day .....

Cans of soft/fizzy drink per day .....

} Consumed in the <u>home</u> not elsewhere

Composting

13 Do you compost any of your kitchen or garden waste?

- ☐ Yes
- ☐ No, but have done so in the past
- ☐ No, have never composted

NOW GO TO QUESTION 15

14 What sort of waste do you compost?

- ☐ Kitchen and garden waste
- ☐ Kitchen waste only
- ☐ Garden waste only
- ☐ Other waste please specify .....

15 What do you do with garden waste, (eg grass cuttings, weeds, prunings etc.), if you do not compost it?

- ☐ I do not produce any garden waste
- ☐ I take it to the Council's waste disposal site and put it in a skip especially for garden waste
- ☐ I take it to the Council's waste disposal site and put it in with the general rubbish
- ☐ I put it out with the other rubbish collected by the Council
- ☐ I burn it on a bonfire
- ☐ Other, please specify

Now some questions about your household

16 Which of the following does your household possess or have access to? Tick all the boxes that are true for your household.

- ☐ Use of a car
- ☐ Garden
- ☐ Allotment
- ☐ Compost heap or special compost bin
- ☐ Garden bonfire
- ☐ Sink disposal unit
- ☐ Microwave
- ☐ Pet cats or dogs

Fridge and freezers (tick one box)

- ☐ Large/chest freezer (bigger than a tea chest)
- ☐ Small freezer (e.g. fridge/freezer)
- ☐ Fridge with ice-box only
- ☐ No fridge at all

17 Which of the following best describes your type of home? Tick ONE box.

- ☐ Detached house
- ☐ Semi-detached house
- ☐ Terraced house
- ☐ Multi-occupied (house divided into flats)
- ☐ Walk-up flats
- ☐ Tower blocks of flats
- ☐ Bungalow
- ☐ Other

18 Do you own your home or are you renting? Please tick the box which best describes your household.

- ☐ Owner-occupier
- ☐ Renting from the Council
- ☐ Renting from the Housing Association
- ☐ Renting from a Private landlord

19 How many people (children and adults, including yourself) live in your household?

.....

20 When did you first move into your current home? Tick one box

- ☐ Before 1st May 1996 (last year)
- ☐ Since 1st May 1996 (last year)

21 How many people, including yourself, are there in your household in the following age groups? Tick <u>all</u> the boxes which apply to your household.

- ☐ 0 - 4 years ..... people
- ☐ 5 - 15 years ..... people
- ☐ 16 - 44 years ..... people
- ☐ 45 - 65 years ..... people
- ☐ Over 65 years ..... people

22 How would you describe your ethnic origin? Tick <u>one</u> box below.

- ☐ White - European including UK
- ☐ White - Non-European
- ☐ Black - Asian
- ☐ Black – Afrocaribbean
- ☐ Black - African
- ☐ Other - give details .....

23 Please describe the job of the main wage-earner in your household - that's the person who brings in the money, including benefit.

Title or description of job.....

.....

Type of trade, industry of profession.....

.....

Supervisory responsibilities (foreman, supervisor, manager and so on).....

.....

Thank you for completing this questionnaire

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